CONTROL ON THE RAILWAYS

A STUDY IN METHODS

BY

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INTRODUCTORY

One of the most interesting developments of modern times in connection with the working of our railway systems is the use that has been made of telephonic communication in train working and supervision. It has introduced a new set of circumstances into the methods of train working on the British railways. It has given a much greater power of control over the manipulation of trains; and it enables the superintendent in charge to supervise train running currently with the actual working instead of by the former method of reviewing past periods. This not only makes for greater efficiency in getting trains—goods trains especially—more expeditiously over the line, but it has placed a new instrument in the hands of the train operator whose power and effect are only just beginning to be realised. So far it has only been partially installed upon our railways, but it seems likely that it will in the future have much greater effect upon the railway organisations than it has had up to date, and it has already had no small effect where it has been introduced.

So complete are the changes in method that have been brought about that the word "control," when applied to train working, has become invested with quite a new—a technical—meaning. It is used to describe the particular adaptation of telephones and train control boards which constitute the equipment of a centralised train control office.

Whilst I commenced this book as a simple effort to describe the new apparatus—how it has grown up, what it consists of, and how it is made use of—I have, as the work developed, thought it better to deal much more generally with the question of control on the railways, with the view of suggesting that, after all, train control is only a part of that much wider aspect of control of the railway organisation in which every person who occupies any position of responsibility consciously or unconsciously takes a share.

It is in the six chapters (from X to XV) that the new methods of train control are described, and for which I am suggesting that some new word is required in our technical vocabulary; but the problems arising out of the new methods are so varied and of so great an importance that no apology seems necessary for having enlarged the scope of the book so as to point out and discuss some of the wider questions involved. They will commend themselves to all students of railway affairs, whether young or old. The question of the effect of the new apparatus upon individual responsibility is one which lies at the very foundation of all economic considerations, and a clear understanding of this problem is of vital interest to every student of economics and of humanity.

The book does not, of course, in any way profess to be a complete or exhaustive treatment of the methods employed on British railways, which are as varied and as numerous as the departments on the different systems.

I would add that the book has been rendered possible only by the ready way in which the chief officers of the railway companies have allowed me to visit the various stations where the new system is in operation. I must in this connection particularly mention the General Managers of the two northern railway systems—the Rt. Hon. H. G. Burgess (L.M. & S.R.) and Sir Ralph L. Wedgwood (L. & N.E.R.)—to whom I wish to express my thanks. Without the help they so kindly afforded I could not have written this book. The assistance given me by Mr. J. H. Follows, the Chief General Superintendent of the L.M. & S.R., and by Mr. C. M. Jenkin Jones, the Superintendent of the North Eastern Area of the L. & N.E.R., has also been most valuable.

If this volume, by stimulating fresh thought, and bringing discussion to bear on a difficult yet fascinating subject, in any way makes for the further usefulness or effectiveness of the train control machinery, I shall be more than satisfied.

PHILIP BURTT.

WOODTHORPE, HARPENDEN,
January, 1926.

Control on the Railways

CHAPTER I

THE MEANING OF CONTROL

TRAIN control is an expression which has, during recent years, come to have a special and quite technical meaning as the system (described on its applied side in Chapters X to XII) under which, by a centralised and co-ordinated system of telephones, the whole supervision of the train working becomes centralised in and administered from a central office, concurrently with the actual operations and movements on the line at the time.

This supervision and administration of train control by telephone is so revolutionising the methods of management that its application goes to the root of almost every question of economy and efficiency in train working. The detailed methods of carrying out the control system selected for application, and especially the contingent re-arrangement of staff and the duties appropriate to each grade of servant or officer, constitute not only a problem, but a set of problems the bearings of which it is essential should be grasped by all who are occupying, or hoping to occupy, any position of responsibility in connection with train operating upon a railway system. The problems and principles involved are of absorbing interest also to the general student of transport.

It will be well that we should in this first chapter deal with control in its more abstract and theoretical significance. Control is a big word: few words, indeed, in the British language have so varied, far-reaching, and extensive a meaning. From the supreme government of all the daily and cyclic operations of this great world by the Divine Controller of events, to the earliest attempt at regulation—conscious or unconscious—in the human babe of its infantine desires for food, or of its physical activities, there control is in some degree being exercised.

Movement rather than establishment describes the principle of world order in our modern days. The discoveries of science show that the foundation of the material universe is dynamic rather than static; and a science of transportation, as yet little developed, lies behind our efforts to understand how best to control the movements of ships on the ocean highways of the world, or of the railway train or road motors on the railways or highways. Our skilled engineers are still leading the world forward in pioneer efforts after improved methods of travel and traction. Aerial navigation, electric traction, the motor boat, rotor ships; in these and other directions there are still many worlds to conquer: but there are also conquests of knowledge to be made in the more intensive spheres, of how best to control with purposive direction the machines which the inventions and discoveries of the past have already brought into the service of man. The steamship leviathans or the great railway systems are the outstanding typical moving machines of our day in the practical service of humanity, and there is much of both art and science involved in the understanding of how they can be most effectively controlled. It is part of the age-long struggle between man and the mechanical forces around him.

Picture a modern steamer such as the *Homeric* leaving Southampton for New York, and finding her way unerringly through fog and sunshine, daylight or dark, and in spite of all adverse winds and ocean currents, by a direct line to her goal, thousands of miles across the vast wilderness of waters. Well might the sage of old, though he knew nothing of the complex developments of modern times, place "the way of a ship in the midst of the sea" amongst the four things that were "too wonderful for him." Picture again the same steamer, with its engines at work, set across the ocean full steam ahead, but with nobody on board, no-one at the helm; what would be its destiny thus under no control? Would it ever reach any port? Without purposive direction, it would be buffeted hither and thither at the mercy of the winds and waves, and would, if it did not founder under the stress of storm, be before long battered to pieces on the rocks. Here we have the contrast between control and the want of it. Purposive direction lies behind " control " used in its larger sense—in the sense we want to keep before us in this study.

Immense is the difference between the modern ocean liner, with its luxurious internal equipment, its thousands of passengers and wireless telegraph fitting and electric light, and the compassless, steamless little ocean barge of Solomon's time ; but only a little less in degree is the difference between the comfortless passenger train of 1850 in this country—when it was necessary for Parliament to intervene to ensure that passengers should be protected from the weather and provided with seats, when signalling and efficient brakes were unknown—and the passenger train of three-quarters of a century later, which forms part of the present railway system of the world, with its 741,000 miles of railway, and its wonderful express trains, luxurious in comfort, with their sleeping and dining accommodation, barbers' shops, libraries, and bathrooms on board.

There are three great factors to be borne in mind in connection with the developments of recent years which add enormously to the difficulties and complications in the control of railway systems by the administrative management.

1. Greater solidarity in the human world as a whole.
2. The much greater degree of co-operation between human units engaged in common enterprise.
3. The great increase in power that any one man can wield in virtue of the development of mechanical or physical aids.

1. *Greater Solidarity in the Human World.*—This is itself the result largely of the development of transport—particularly as we include in transport the transmission of intelligence: London is conversant with what is going on daily in Japan, China, California, and South Africa, in a way that was impossible—almost inconceivable—half a century ago. India listens in daily to the affairs and news of the world at large. Much more now, even than when the poet wrote the line, is it true that " Mankind are one in spirit," and in any given country, such as our own, a unity of action is possible between

the far-distant corners as never before. General Smuts has aptly said: "The cardinal fact of geography in the twentieth century is the shortening of distance and the shrinkage of the globe." This constant drawing nearer together of people at opposite ends of the country under the influence of telephones and telegraphs must lead inevitably, sooner or later, to a growing consolidation of interests. And what further, we may query, are wireless and broadcasting going to do for us in this respect?

Each of our large railway companies is now made up of an aggregation of a large number of constituent smaller companies. The new Railways Act of 1921 carried the process of consolidation a very important stage forward, and enacted that the 109 railway companies then existing must be consolidated into four large systems by July 1923. Mr. Cleveland Stephens, writing in 1915* about amalgamations, spoke of the railway system of Great Britain as the consolidated outcome of more than a thousand separate undertakings of earlier days. This process of consolidation is having a tremendous effect upon the question of control. The London, Midland and Scottish Company, whose largest constituent company in 1921 covered 1,758 miles, has emerged from this process of consolidation with a mileage length of about 7,214; and whilst a particular system or method of control may be fitted, and quite apposite for the smaller number of miles, it by no means follows that the same system will be equally successful with a much larger unit. Moreover, each of the several units had its own established description of control system, and no doubt has adopted its own particular method as suited to its particular needs and circumstances. Now that the various separate systems have been combined under one management—the L. & N.W. with the Midland, for instance, or the three companies, G.C., G.N., and G.E.—much discussion and negotiation is taking place, and must continue for some time to take place, before a unified system can be evolved. But consolidation is taking place, and it is bound to lead to more and more unification in the control arrangements, whether it be control of train running, or of locomotive and wagon distribution, or of the control which a board of directors, or the voice of democracy expressing itself through councils or tribunals, is going to exert in the future.

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* *English Railways; Their Development and Their Relation to the State*, Routledge, 1915.

2. *Greater Co-operation.*—As civilisation develops the reign of the competitive spirit—in Darwinian phrase " the struggle for existence," in more colloquial terminology "each for himself and devil take the hindmost "—must more and more give way to the principle of mutual help and co-operative assistance. Adam Smith shows luminously in his *Wealth of Nations* what an enormous increase in power for the production of wealth may be obtained by the adoption of the principle of division of labour ; and in modern industry what is known as " mass production "—this principle of division of labour combined with co-operation—has reached its high-water mark in a modern factory.

Henry Ford,* in his record of the development of the Detroit industry, tells a romantic story of the way this principle has been introduced in the production of motor-cars. Following a device of the Chicago meat packers—an overhead trolley—the idea of bringing the parts of a fly-wheel magneto to the skilled erectors by machinery instead of by human movement was adopted, and each man was given a specific stage in the assembling as the various parts moved in line past him ; and the time of assembling was reduced from 20 minutes to 5.

In the assembling of a chassis are 45 separate operations. The first men fasten four mud-guard brackets to the chassis frame ; the motor arrives on the tenth operation, and so on in detail. Some men do only one or two small operations ; others do more. The man who places a part does not fasten it—the part may not be fully in place until several operations later. The man who puts on a bolt does not put on the nut. The man who puts on the nut does not tighten it. On operation No. 34 the budding motor gets its gasolene ; it has previously received lubrication ; on operation No. 44 the radiator is filled with water, and on operation No. 45 the car is driven out into John R. Street.

The same ideas, says Mr. Ford, have been applied to the assembling of the motor, with the result that the assembling, which in October 1913 required 9 hours and 54 minutes of labour time, occupied six months later by the moving assembly method 5 hours 56 minutes.

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* *My Life and Work,* Henry Ford.

This division of labour method seems to have been the secret of the Ford Works wondrous performances—1,250,000 cars produced in one year, with a minimum wage in the factory of 25s. a day—an 8 hours' day.

The gradual substitution of combination and co-operation for competition in the railway world is a fruitful and interesting study in itself. That competition between company and company is good for the public who use the railways is a view that has always been held by a large section of traders and travellers, and is likely to be so held for years to come. But it is a narrow view at best, and will gradually give way to the saner view that co-operation in its widest aspect, under enlightened guidance or control, is the most effective principle in productive industry, and that which will produce the best results for the community at large.

When a Parliamentary Committee, appointed in 1882 to consider carefully the whole question of railway charges, in its wisdom gave the go-by to the principle of "equal mileage rates," it at the same time reflected the popular view of the advantages of competition to the public. The railway companies who conveyed sugar from the refineries of Greenock to Nottingham and the industrial area of the Midlands, were charging the same rate—about 25s.—as the companies who carried from the Thames refineries in London, just about half the distance away. Naturally the London refiners and the Southern Railway Companies raised objection; but the Parliamentary Committee, pointing out that it was good for the consuming public to have the sugar in competition in the Midlands in order to keep down prices, justified the Scottish and Northern Railway Companies in their action.*

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* Thirty-nine towns in England to which sugar is sent are at an average distance of 292 miles from Greenock, and the same towns are at an average distance from London of only 156 miles. The rates for these distances from London and Greenock respectively are about the same. . . . This competition cannot but be advantageous to the public. That Greenock sugar refiners should be in the same market as the sugar refiners of London, while it may be a grievance to London refiners, must be an advantage to Greenock refiners and cannot be a disadvantage to buyers of sugar.—Parliamentary Committee on Railway Rates and Fares, 1882.

It may be true that our railways in Great Britain have attained to their present magnificent position through private enterprise and competition. It is true that Parliament has ever since 1853 maintained a traditional view that too powerful combinations of the great railway interests were dangerous to the common welfare of the nation. But it by no means follows that because our present railway position has been attained under a highly competitive system that, under the new and different conditions of to-day, the competitive principle is as necessary to future development as it has proved efficacious in the past. Indeed, it has never been a satisfactory method of regulating railways. Gladstone in Parliament in 1844 expressed himself as considering it as quite inadequate: "Competition cannot be relied on to secure proper service and a fair price," said the influential Joint Committee—of Lords and Commons—on Railway Amalgamation in 1872. There is much to be said for the view that unregulated competition belongs to a lower order of human society; that a new era is now needed when the competitive instinct is brought more under control, and gives place to a régime of combination, co-operation, and good-will, and that only under such régime, with the railway house undivided against itself, can we rationally hope to hold our own in the growing international competition.

The Railways Act of 1921 owes its provisions for consolidation and other railway developments largely to the faith of its promoters in the necessity of a larger measure of co-operation and less competition. And the new methods of telephonic control would appear to be practicable and capable of successful development in a large homogeneous unit when they would not work efficiently under a system of competition with greater heterogeneity.

And it would seem to be equally true that this method of rapid exchange of intellectual views under an ever-widening area itself makes for greater solidarity and homogeneity.

3. *Increase of Human Power in Control through Improved Mechanical and Physical Appliances.*—This increase practically involves the whole history of the development of human tools from the bow and arrow or spade of the primitive man through successive stages represented by plough, cart, tramway, rail-

way system, electric traction, telephone, wireless telegraphy, automatic control, and so on. It is a long record of evolutionary development, and as we survey the record, and observe how the tool was in the course of time superseded by a machine,* the simple machine gave place in turn to a complex steam engine, the steam engine has been followed by electric trains and trams, and the electric telegraph by wireless, it should be noted that there were two steps which appear to stand out as epoch-making more than others, namely, when man discovered how to control steam power and bring it into his service, and, secondly, when he discovered how to exert similar control over the electric current for purposes of traction or other application of power. The modern train control apparatus is dependent upon the discovery and development of all these factors, and represents one of the most advanced stages in the application for human service of a complex apparatus which combines mechanical arrangements, steam power, and electric current.

It is well we should remember that a railway system is itself a machine. It is probably the largest machine for the creation of wealth in the material sense that a nation or country possesses. And its main function is the creation of wealth. The goods which the railway carries become valuable by virtue of their being brought from places where they are of little use to the place where they are needed and have greater exchange value. Often the mere railway journey converts a worthless article into one of considerable value. From the point of view of practical economics, we may rightly regard the railway system of any country as a gigantic wealth-creating machine. The control of this machine becomes very complex, its complexity being measured by the degree in which a railway system, with its thousands of locomotives and moving trains, exceeds in complexity one simple locomotive or one motor-car. We shall consider very shortly some of the principal directions in which control in a railway system needs to be exercised.

Let us consider first, however, an essential difference between the control of a railway engine and a road motor. The chauffeur of the latter has to control his motor not only in the sense of regulating the power by which the machine is propelled, starting, stopping, and regulating the speed, but he determines its direction also; indeed he has his hand continuously on the steering wheel, and the control of the direction of his motor is as important as the regulation of the power—the two go together. The railway engine-driver has nothing to do in determining the *direction* in which he is travelling (except as between going forward or backward); that is arranged for him by others—his time-table schedule and his signals. Although he controls, he does not in any sense *direct* his engine. The motor chaffeur *both controls and directs* his machine. This is an important difference, and an interesting one in its psychological aspect.

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* A tool, it has been said, assists a man to do his work: a machine actually does the work and requires only human guidance or control.

In some countries where science has perhaps freer play in practice than in England—or at any rate where psychology obtains a wider measure of application—psychological tests are applied in selecting candidates for the position of chauffeur, these tests being aimed at discovering the degree of capacity in the individual for taking in quickly the factors in a group of circumstances into which the man is suddenly thrust (as, for instance, the chauffeur coming towards a street corner amidst traffic), and, secondly, having grasped the situation (i.e. the multitude of circumstances which make up the situation), the capacity for quick and accurate judgment as to action. The two faculties are quite distinct, and great is the difference between man and man, in quickness of accurate perception, in making decisions, and in practical action.

We are now in a position, having enunciated the view of a railway company as a complex machine, to consider some of the directions in which the controllers of the machine have to exercise their function. Let us name four that will occur at once, namely:

1. In the daily operations of any large goods or passenger station;
2. In the daily distribution of the carriage and wagon stock;
3. In the economical distribution of the available locomotive power;
4. In the manipulation of the trains to best advantage in their use of the running lines.

Consider now each one of these functions seriatim. We shall deal with them in greater detail in later chapters; but it will be well at this stage, and before getting into greater detail, to try and grasp the character of each of these four functions, if only to help to a clearer understanding of what is meant by the principle of control as applied to railway working.

1. *The Daily Operation of any Large Station.*—Take a survey at random of any goods station at a large town, when the goods are coming in from the town for despatch by rail. What do we find? Often a perfect medley of traffic, apparently chaotic: all descriptions, sizes, and shapes of consignment—boxes of bacon, bags of yeast, sugar, cotton, pianos, eggs, wire, sewing machines, perambulators—coming in quick succession into the goods station, destined for hundreds of places scattered throughout the United Kingdom, but laid haphazard on the goods station bench. These, by all sorts of permutations and combinations, have to be placed into wagons so as to bring together all the separate articles for any specific destination, so that they may be loaded in one wagon; and in the same way the wagons must be brought and placed in the station shed in such a way as to economically receive and convey to the right destination station the appropriate collection of goods. Behind all this medley of goods traffic is an organisation which controls the whole operation—the receiving, sorting, and economical loading up and despatch of all the goods. Only by an efficient organisation, i.e. by careful control, can the work be effectively dealt with. In this case we see an illustration of a general theory that efficient organisation is of the very essence of control—one of its most important elements. We shall subsequently describe in greater detail the organisation of a typical goods station (see p. 29).

2. *The Daily Distribution of Carriage and Wagon Stock.*—Here again organisation is of the essence of satisfactory control—a central office working through district representatives (district controllers), who in turn have supervision over a large number of detail despatch and reception points (railway stations); but in addition to a good organisation in personnel, much information in the way of daily and monthly records and statistical information is requisite and, indeed, is a *sine quâ non.* This also will be dealt with in due place. The office

of rolling-stock *controller* is an old-established institution on most railway systems.

3. *Economical Distribution of Locomotive Power.*—The considerations set out in regard to rolling stock in the last paragraph apply largely to the case of engines also ; with the difference that a number of additional factors arise, which makes the allocation of locomotives a more responsible business, requiring more technically trained intelligence than is the case with carriages and wagons.

Is the mechanical construction of the locomotives best suited to the work they have to do ? The proportion of this or that class of locomotive requisite to haul the traffic on the different grades of any particular district : the reduction of the number of types of locomotive to a minimum consistent with economical haulage ; the interchange between passengers and goods service—all these questions or factors have to be carefully considered, and, under the changes in the areas of the railway systems which have recently taken place under the amalgamation schemes, they all have to be considered afresh in the light of altered circumstances.

A large railway company has now as many as 10,000 locomotive engines under one supervision, representing value up to £8,000 or £10,000 or more each, and one of the great questions inevitably affected by this question of control is whether the supervision of the locomotives when *in daily working* should be under the trains superintendent (i.e. the superintendent of the line), or under the same control as are the construction and repairs of the engine, i.e. the chief mechanical engineer. Until recently it has been the latter; but there is a growing tendency for the supervision of the machines to go along with the supervision of train running. This question will necessarily have to be dealt with when we come to consider locomotive control.

4. *The Manipulation of Trains to Best Advantage in Their Use of the Running Lines.*—It is here where the question of control has received its greatest development and most advanced application. Here let us state in a sentence or two what has been achieved, mainly by the agency of efficient telephones and trained operators. A railway company is now able to bring the whole of its trains under one central

control in the following manner. A central office contains a diagram board of all the running lines, signal boxes, and control points in the area under control, and every train, as it moves from point to point, is placed by means of a peg on the geographical diagram, so that the chief operator in the control office has before him—as pawns on a somewhat complicated chess board—all the trains working in his area, and can "operate" the trains to greater or less advantage, as though he might be working out a game of chess, his aim, however, being not to checkmate an opponent, but to secure for all his men as much free movement as is possible under a co-ordinated scheme. How this highly complex game of chess can be played to best advantage it is the main object of this book to discuss, such discussion necessarily involving a description, not only of the various systems employed, but also the varying methods of its application.

It will probably already have been noticed, as the above headings have been contemplated, that the exercise of control in supervision divides itself along two main avenues of influence, namely: (1) Control of mechanical movement; (2) Control of the personnel, so that every human unit in the organisation may be occupying his right place in relation to every other.

In the higher branches of organisation of a railway system it is often very difficult to separate these two directions of control—they are necessarily so inter-related. We have, in referring to the difference between a motor-car and a railway engine, illustrated what we mean by control of mechanical movement, and of this control we shall have much to say as we continue to develop our theme. We close this chapter by a general description of the organisation of a goods station under the control of the goods station master—or goods agent, as he is more frequently called. This organisation will illustrate how—that is through what channels—the agent in supervision exercises his control by efficient organisation; we shall follow this with a similar chart and explanation of the organisation of a passenger station in our next chapter, and these two illustrations may be taken as fairly indicative of the kind of machinery through which *control of personnel* is arranged over a large group of men who are "operating" a station, depôt, or railway yard.

Now as to our goods agent and his staff. The medley of goods consignments referred to earlier on in this chapter is dealt with as follows: As each cart- or rully-load of goods is brought to the station, the goods are handed, consignment by consignment, to a checker, who instructs the goods porters or barrowmen what is to be done with each package, directing him to a particular bench or wagon, he—the checker—being probably assisted by a "caller off," who aids him in checking the goods with the consignment note. The porter takes the package of goods as directed by the checker, to its appropriate berth or, better still, wherever possible to the right wagon which is waiting to receive it. The wagons are each in charge of a loader, and the loader receives the goods from the porter (barrowman), and stows them in the wagon safely; this functionary is on some lines called a stower—a term which fairly indicates the man's function. There will probably be, in any large station, several of these gangs of porters, etc. ("freight-handlers" they are expressively called in America), each working under a checker, who really is an under-foreman, and over all the operations will be one or more foremen, the number of these depending on the size and lay-out of the station. If the checkers are well-selected and experienced men, the duties of foremen may be reduced to a minimum, if the necessity for them is not entirely eliminated. But in most cases, to-day, as a matter of fact, both foremen and assistant foremen are to be found at all large stations. The foremen are directly responsible to the goods agent, subject to this variation, that where the working of the goods station is under the supervision of the superintendent instead of the goods manager, the foremen are then responsible to the district superintendent, and very often, in such a case, an intermediary "yard master" is placed as the direct supervisor. It should be added that, whilst the description just given refers to outgoing traffic, there is a precisely similar arrangement of staff to deal with the incoming traffic, where the operations are, in a manner, reversed, the goods being taken from rail truck to rully or cart, instead of vice versâ.

So far in regard to the "operating" of the goods station itself: but along with every station there is, of necessity, a considerable staff of clerks, dealing with invoices and other

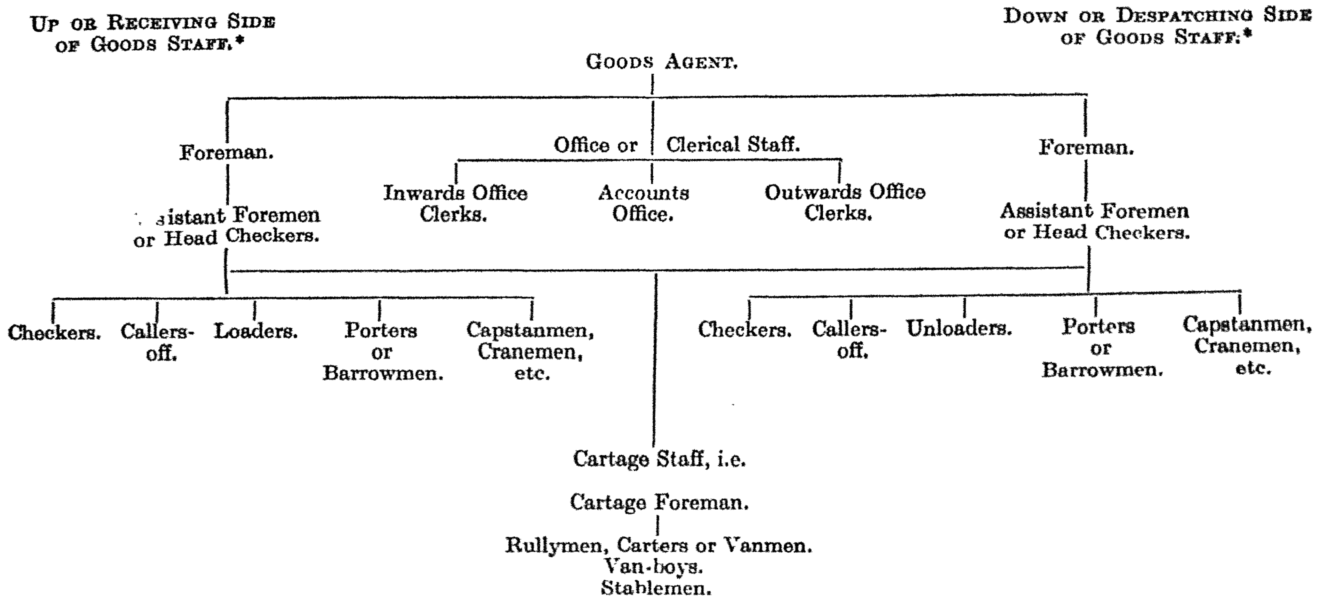
Up or Receiving Side of Goods Staff.*
Down or Despatching Side of Goods Staff.*
Goods Agent.
Foreman.
Office or Clerical Staff.
Foreman.
Assistant Foremen or Head Checkers.
Inwards Office Clerks.
Accounts Office.
Outwards Office Clerks.
Assistant Foremen or Head Checkers.
Checkers.
Callers-off.
Loaders.
Porters or Barrowmen.
Capstanmen, Cranemen, etc.
Checkers.
Callers-off.
Unloaders.
Porters or Barrowmen.
Capstanmen, Cranemen, etc.
Cartage Staff, i.e.
Cartage Foreman.
Rullymen, Carters or Vanmen.
Van-boys.
Stablemen.

Fig. 1.—Goods Agent's Staff Chart.

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* The Staff (other than Office Staff) at most goods stations work up and down traffic alternately as one staff: at a few stations there is a separate organisation of staff for each side.

necessary documents. These are divided as between outgoing and incoming traffic (in London generally known as "down" and "up" traffic respectively), each of which is headed by a chief clerk—chief inwards clerk and chief outwards clerk respectively; these two chief clerks, along with the chief accounts clerk, have direct access to the agent, and come under his direct control.

Then there is the whole of the cartage staff: rullymen, vanmen, or carmen, as they are variously described; they, with their varying equipment, horses, vans, motors, and stabling, also come under the control of the station agent, very often being directly supervised, on behalf of the agent, by a cartage foreman.

A diagram is the best way of showing how all these various grades and officials are co-ordinated and brought under the control of the goods station chief—the agent—and such a diagram is given on page 30, and indicates the avenues along which the agent exercises his control. This is the machinery of personnel, by which alone it becomes possible for an agent in charge of a large section of transport business at all effectively to conduct, in harmonious and orderly procedure, the multifarious activities for which he is responsible in the manipulation of the goods brought into his custody for transmission by rail.

Thus by the organisation of personnel, and by every man having his own appropriate function allotted to him, whether as checker, caller-off, barrowman, or loader, and each being told off to his right place in the organisation as a whole, the heterogeneous mass of goods destined for places scattered far and wide throughout the country finds itself sorted out and loaded into appropriate wagons, each in its turn finding its right place on a moving train, all working in due order and decorum according to pre-arranged plan. It is a matter of organisation, and ultimately control.

In Chapter VII we point out how vastly the telephone increases the facility and the powers of supervisory control in circumstances of this kind.

CHAPTER II

CONTROL THROUGH ORGANISATION

THE efficiency of any organisation may be measured by the ease and effectiveness with which control of its affairs is administered and maintained by its governing body.

We have given a diagram of a goods agent's organisation such as may be found at any large goods station. The goods agent must be in a position at any moment to obtain information as to the whereabouts of any goods in the railway company's custody or to give any instructions to the staff acting under him in regard to any orders or advices or letters he may receive from the senders or receivers of goods—the company's customers.

For this the organisation shown in the diagram exists; and it is essential to orderly working that a clear line of authority, as shown in the diagram, be observed, and this point in regard to clear authority becomes of greater importance in the higher ranks of the organisation.

The final control in the organisation of a railway company, according to present British methods, is in the hands of the board of directors. They select and appoint the general manager of the system and he is the supreme executive head of the concern. If there is one person entitled to the designation of ultimate controller it is he. It is his function to interpret to the working staff the policy of his board: and, subject to this principle that he must understand and give effect to the views of his board as a united council, the general manager is a supreme controller. His control in turn is exercised through trusted subordinate officers, whose function it is to keep in constant touch with their chief, the general manager, and then each in his own department see that the daily work therein is carried on in interpretation of, and in harmony with, the known views of the general manager and the instructions received from him. The principal subordinate officers on the working side of the railway are: (1) the general superintendent, (2) the goods manager, (3) the passenger manager, (4) the engineers, civil and mechanical. There are other officers, such as accountant, storekeeper, solicitor, but these have no direct responsibility for the daily working of the system.

If now some fresh instruction or general order requires to be given, say, for instance, that holidays must as far as possible be suspended during August for special reasons, the order will be given first by the general manager to his departmental heads, the general superintendent will communicate the same to his district superintendent, he in turn will advise all his station masters and others concerned, and the station master has then the responsibility of telling everybody under his supervision or control of the instruction that has been sent down.

Thousands of requests come every day to the railway companies for goods to be despatched promptly or to be handled under special arrangements or conditions. With these the general manager does not concern himself, nor, unless there is some special point of difficulty or of principle involved, does the head of the department. If such request is addressed to the general manager, it is, as a matter of routine, handed at once to the goods manager or general superintendent, or whichever officer may be concerned; and he in turn will immediately pass it on to his district representative, the latter making whatever arrangements are necessary with the station or stations concerned. The higher officials would only consider the matter if there were some unusual circumstance connected with it; and usually such special consideration would come up as a point referred to higher authority by the subordinate officer when he felt that he ought not to deal with the case in any special manner without authority, or should he wish to consult his superior officer for guidance or advice.

By a carefully arranged organisation of this kind a railway company moves forward in providing for the public an effective and convenient service for the conveyance of passengers and commodities, and acts as one great institution inspired by a common ideal and actuated by a common aim, that aim being the provision for the community of the utmost of services and facilities for the expeditious and safe transportation of passengers and goods. In the pursuit of this aim its central function may be said to be the efficient conveyance of traffic, which is given effect to by the running of constant train services as required.

And now we must repeat one of the points of our last chapter: there are two main descriptions of control which must be kept in mind in a study of this question, viz. the control over the movement of trains and the control over the services of men. The provision of an efficient and convenient train service for the public needs is the central objective, and to secure this the fitting of every officer or servant of the company into his right niche so that the organisation as a whole may pull together to secure that the highest service is rendered to the commonwealth: this is the great test of control which is always before the board and general manager.

The direct supervision of the mechanical service of the railway company, the provision and allocation of engines, carriages, and wagons, and the arrangement of trains, is the province of the general superintendent of the company; and as it is that branch of railway work that this book is primarily concerned with, the larger organisation of the company is only introduced so that a right perspective may be obtained of the position which train working occupies in the railway system as a whole—the setting, so to speak, of the question of train control in the larger scheme of the organisation as a whole.

The query may not unnaturally be asked in these days of large amalgamated railway systems whether the extent of territory and the size of organisation has not become too large for any one man or group of men effectively to exercise control or authority over them.

The personnel of the L.M. & S. Railway system now numbers 274,523 employees, against 133,940, the maximum number employed on any one system in 1922, and it may be stated at once that, unless the inventions of science had come to the aid of human intellect in the matter of railway supervision, efficient control would have been impossible.

It is difficult for any of us to realise to what extent such an instrument as the telephone has become part and parcel of the regular routine of management. Not only has it enabled consultations to take place more readily and decisions to be taken more swiftly, but it enables different minds to work in co-operation in deciding upon any definite course to be taken in a way which some thirty or forty years ago had never been dreamt of. But it is not only to the telephone that we are indebted for modern improvements in methods of administration, but to many other scientific factors. Systems of card indexing, automatic devices, power application to machinery, statistics, diagrams, and graphs are only some amongst numerous devices and developments which might be mentioned as having come to our aid.

Statistics as to traffic tonnage and receipts, coupled with diagrams showing ton-miles worked per engine-hour, will give to the general manager of to-day a visual indication whether the development of railway traffic is satisfactory or otherwise, and whether it is being worked economically. In these two factors he has, as it were, a barometer pointing out to him whether the weather is likely to be fair or stormy; or perhaps a better analogy would be the clinical thermometer, which is an indication to the doctor as to whether his patient is in need of medical treatment.

Within the departments, however, much greater use has to be made of these instrumental aids to management. The goods manager, for instance, must have statistics showing traffic receipts and tonnages, district by district or town by town and station by station. The general superintendent, on the other hand, requires to have graphs as to train running, statements of punctuality, wagon distribution, carriage requirements, and a host of other summaries, as well as constant telephonic communications with his district officers, and for efficient train supervision he must now bring into play the new methods of supervision and continuous watching of the running of trains known as central telephonic train control, which it is one of the principal purposes of this book to describe.

We have referred to the central function of a railway company as being the efficient conveyance of traffic; and when the steps necessary in the public interest to give effect to this aim are considered, it will be seen that they may be narrated under the following heads :

(1) To secure traffic for conveyance.
(2) To collect traffic destined for railway transit.
(3) To arrange acceptance of traffic needing to be forwarded.
(4) To despatch traffic from Station A to Station B.
(5) To convey such traffic in as expeditious and economical a manner as possible.
(6) To deliver traffic safely at destination after train conveyance is completed.
(7) To arrange to levy and collect appropriate charges for conveyance or services rendered, or for other services contributory to conveyance.

These seven headings describe the principal functions of our British railway system. There are, no doubt, other functions which might be mentioned, but they will probably fall under one or other of the comprehensive headings above set out. For instance, to advertise, to issue time-tables, to compile rate-books. Advertising is subsidiary to the security of traffic, heading (1). The issue of time-tables is also necessary to secure traffic, heading (1). The compilation of rate-books is part of the function of compiling and levying appropriate charges, heading (7), and so on.

With these headings before us attention should be drawn to headings (4) and (5), the work of despatching and conveyance of traffic as being the central function of a railway system. They are the functions which make up the "operating" of the railway system, and over which in the more modern railway organisation the superintendent of the line or the general superintendent is given entire charge.

Goods are brought to the railway, accepted on its behalf, despatched and conveyed by rail, and then delivered to consignee or receiver at destination. The theory of the modern organisation is that, up to the point of acceptance by the railway company, the superintendent's or "operating" department has no authority over the goods : it is the business or function of the commercial departments (goods or passenger

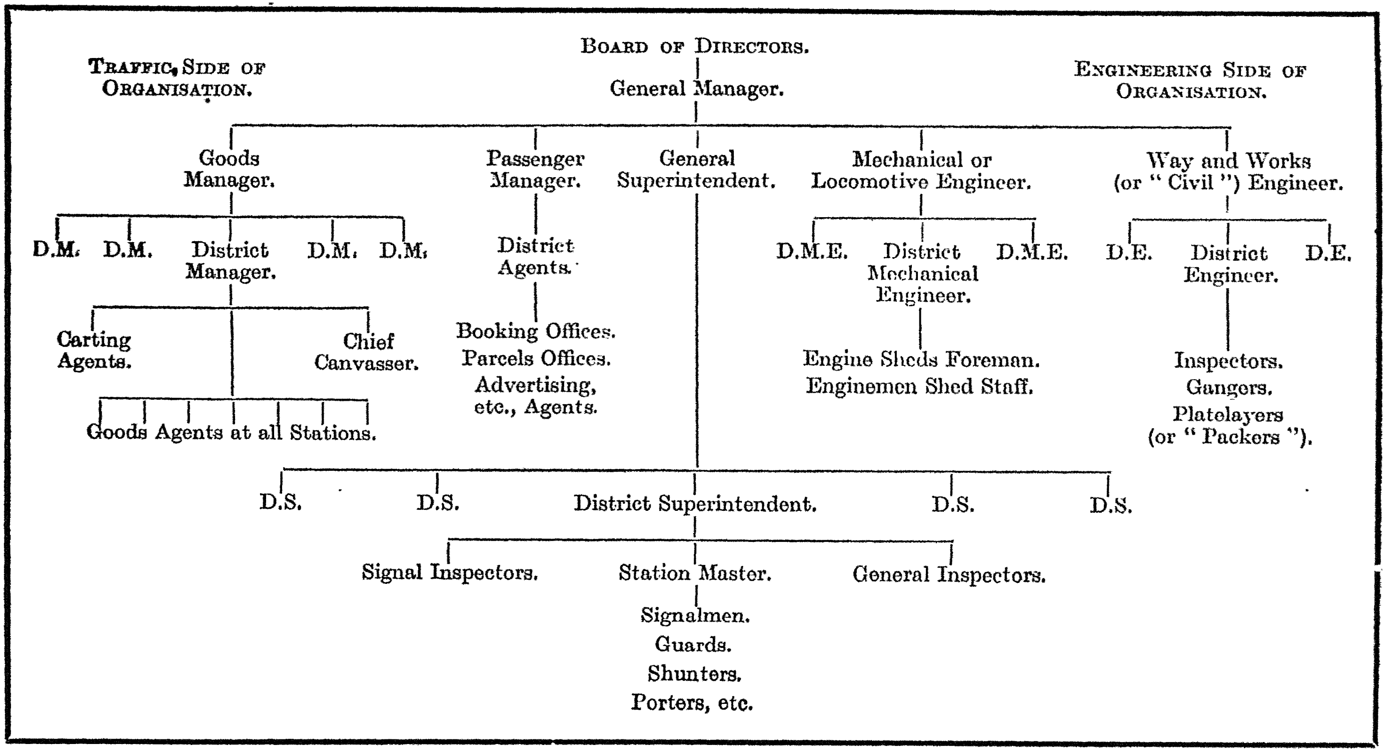

FIG. 2.—ORGANISATION CHART OF A RAILWAY COMPANY.

manager as the case may be) to supervise and arrange for the securing, collection, and charging of traffic; but once accepted, then the "operating" function commences, and the superintendent of the company is entirely responsible.

One of the best summaries of the varying duties of the three sections of the traffic department of a great railway system are those which were tabulated by Sir George Gibb in 1902, when as general manager of the North Eastern Railway he re-arranged the duties of that organisation upon lines which have since been largely followed by other railway companies in Great Britain. It is there set out that of the three officers at the head of the traffic department:

The general superintendent is charged with the administration of the department of the company's business connected with the running of trains, and the handling and carriage of traffic of all kinds on the company's railways, docks, and wharves.

The passenger manager is charged with the administration of the department of the company's business connected with securing and charging for passenger traffic, and all traffic carried by passenger trains (including fish carried under fish waybills).

The chief goods manager is charged with the administration of the department of the company's business connected with securing and charging for goods traffic (i.e. merchandise, live stock, and mineral traffic, except fish carried under fish waybills).

Reference to the diagram on page 37 will show how, i.e. through what line of authority, the general superintendent exercises supervision or control over the staff in direct charge of the train, under the theory of supervision now generally recognised. The new telephone control system seems often to take a short cut in the exercise of direct control over the working of trains as they are actually in movement over the rails, and it is a factor which is responsible for affecting in no small measure the organisation of the whole railway system. In later chapters this question is dealt with in some detail.

CHAPTER III

A STATION MASTER'S CONTROL

AT the end of Chapter I an illustration was given in the case of a goods agent's control of how the organisation of personnel operates through a local office or department. In this chapter it is proposed to describe in some detail the duties and organisation of a station master at an important station, as an understanding of a station master's duties will provide a link between the general organisation of the company and the grades of service, station masters and signalmen in particular, who come more directly in contact with the mechanical details of train working.

A station master may have direct supervision over from one to five or six hundred servants at his particular station, through whom he directs the control of trains and traffic. The main function of a station master—to which all other duties are more or less subsidiary—is the efficient control of the movements of trains within his particular area. This is what is technically known as train "operating." In this matter we come into direct contact with train working—the mechanical operating of the great railway machine; and in the station master's efficient control we shall see especially how closely intermingled are the two lines of control, mechanical and personal. The mechanical control is exercised through supervision of the signalmen, and the station master should be a past master in the art of signalling if he is to be really efficient in control over the movement of trains.

The best way to grasp the true position of a station master's control and its variety and extent is probably by a perusal of the diagram given on page 40. The diagram includes not only the personnel *under* his supervision, but also the general and district superintendents, so as to show the station master's

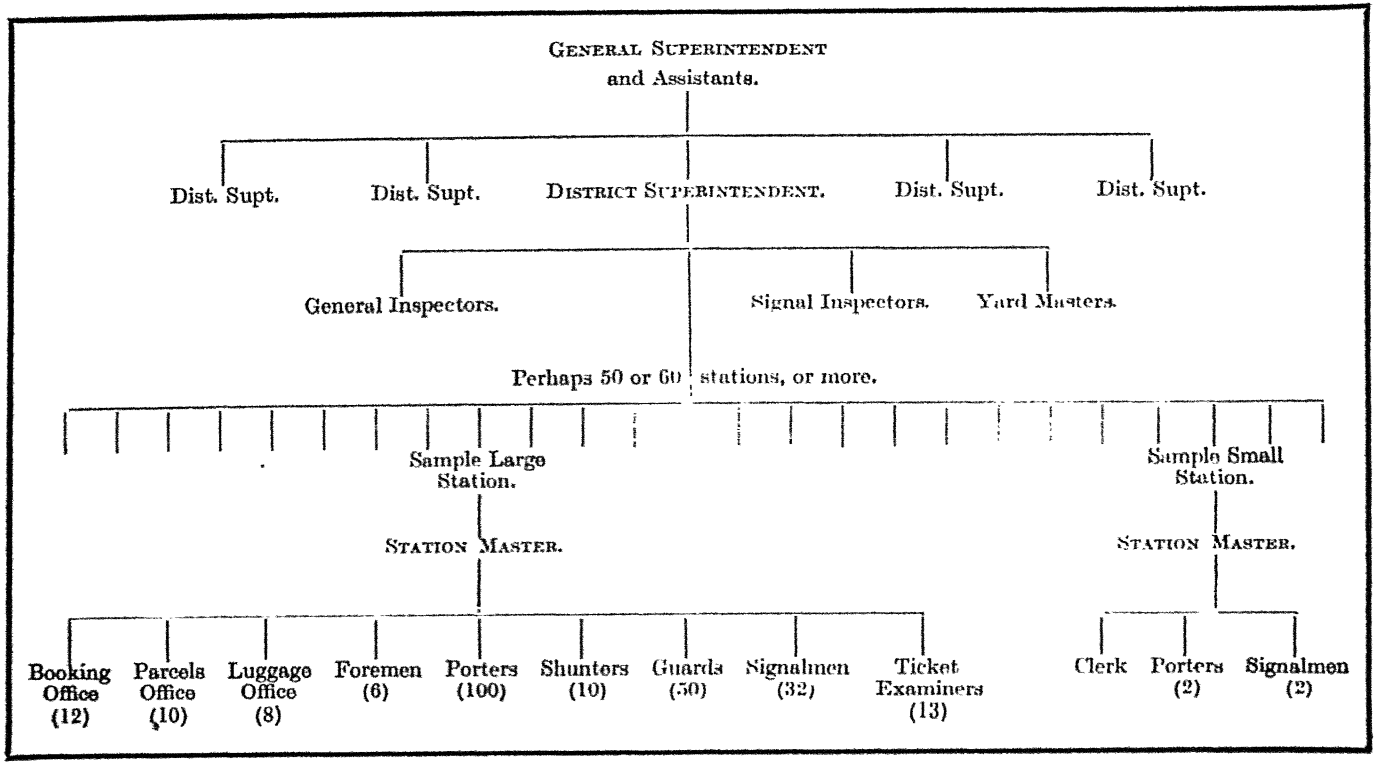

FIG. 3. DIAGRAM CHART OF SUPERINTENDENT'S DEPARTMENT, SHOWING STATUS OF STATION MASTER.

relationship to the head of his department, that department which handles the control of trains.

It will be noticed that the general superintendent and the assistants in the central office have authority over five district superintendents—there may be more or less—each of whom is in charge of an important district, and each district superintendent may have fifty, sixty, or more stations under his immediate supervision and control. It should be noted that there are stations of all sizes, from the small rural station to the large depôts and terminals which serve our larger and more densely populated towns. A typical organisation or personnel for a small country station would be (and this also is indicated in the chart) a clerk, two porters and a signalman—with, of course, the station master, who is the company's representative in that place. But at a large station there are clerks in the booking office, in the parcels and luggage office, respectively, and also foremen, porters, shunters, guards, signalmen, and ticket examiners, in widely varying proportions. Typical numbers of each grade are set out in the diagram.

The duties and functions of signalmen are the only ones we need refer to in connection with our special subject of train control, but these are all important. The diagram indicates clearly how the signalmen stand in order of grade in relation to the superintendent's department and to their co-ordinate colleagues.

We must again refer at this stage to the engine-drivers. Let us recall the comparison we drew in our last chapter between the locomotive driver and the chauffeur of a road motor. The latter has to select his path as he propels his vehicle forward ; he has to direct his machine as well as drive it. Not so the railway driver ; he drives his train forward, and starts or stops it, keeping it under continuous control ; but he cannot direct ; he cannot deviate to the right or left, or choose which road he will take at a junction or bifurcation. All this is regulated for him, and as regards his course and whether he is to stop or go forward, the one injunction for him is "obey your signals." The controlling factor is the series of signals which tells him the direction he has to take, and whether the line is clear or blocked in front of him, and at a complex point of concentration enables his engine to pick out its right track amongst many diverging lines of way. This, however, is arranged for him by the signalman. The signals are the main instrument of control in train running. So we have a great and continuous army of signalmen and array of signals all along the railway track, and the function of the railway semaphore signal is to indicate to a driver "line clear" or "line blocked."

There are about 32,000 signalmen employed on the railways of Great Britain to-day. At a large station there may be fifty or one hundred or more signalmen employed. The station master is in command not only of the signal-boxes, but also of the entire train movements in and around the station, and also of the whole of the personnel included in the diagram below the line of the station masters. One of the chief qualifications of a station master is, we have already indicated, a knowledge of signalling; he could not himself control the signalmen without adequate knowledge "on his own" of the principles, as well as a practical knowledge of the details, of train signalling. There are circumstances, especially at small country stations, where it is found, for one reason or another, desirable or necessary to appoint as station master a man without any signal experience, and then such man is entirely dependent on his signalmen for any technical question as regards signals. In such cases it is very likely that some little difficulty in supervision will sooner or later occur, and in any event it is not an enviable position for a station master to find himself in. At a large station the circumstances are different; the station master will probably have two or three assistants, who can help him in supervision: he is in command or captaincy of a small army, and, like the captain of a ship, his duty is on the bridge—to keep a look-out, to watch.

Some of the best station masters the writer has known, at large stations, where there is a great concentration of traffic, and where there is also a footbridge or signal bridge in a commanding position at the station, have, in times of emergency—on special race or gala days—made it a practice to post themselves literally on the bridge, so as to get a survey of the general movements in the station, and from there have given instructions to their assistants, as the latter have come for guidance in their difficulties, or have entered into consultation with the signalmen as to precedence of trains, or upon some question of importance in the working.*

The station master at a large station has so many and such varied functions that he should be of such calibre as can take a detached view of things, and think things out. To think things out requires time, and there are many problems every day which arise for solution in the common round and the daily task of a station master at places like Euston, Paddington, or Birmingham which need careful and detached thought. Mr. A. M. Ross, in his little book on *British Railways*, gives a good definition of station masters' duties which is worth repeating in full as he gives it :

> "The Station Master is the chief executive official in and about a station to which he is attached, and is responsible for the proper working of the station in every respect---for the control of the staff, including porters and signalmen, the supply of stores, the management of the trains within the area of the station, the issue of tickets, and the custody of money received and the responsibility for all that is paid out. At an important station the Station Master has a wide discretion and large responsibility in supervising many diverse operations and a large body of men. At a small station, though sometimes the Station Master may have practically to manage the whole of the duties without assistance, yet the variety of them requires a man of experience and judgment."

Amongst other things it must be remembered that the station master is the local representative of the railway company in the immediate district, and that in itself increases not only his responsibility but also the need for his being thoroughly *au fait* with all the railway arrangements affecting his locality.

But the station master's line of train control is, we have said, through the signalmen, and to the signalman's duty we must now turn. We may describe the staff at a principal signal-box at one of the busy stations. The following organisation represents that at a manual lever cabin : the difference between manual and power controlled levers will be fully explained hereafter.

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* At certain stations in or near London it is the practice to have an important yard master, or traffic inspector, to undertake this supervision under the station master's control.

The main equipment of a signal-box is the "frame" in which the levers are fixed, the levers controlling signal semaphores, crossover points, junction points, locking bars, etc. The levers are all numbered, and a key diagram or plan of the lines within the station limits, which shows all the points, signals, etc., carefully numbered to show to what each lever refers, is hung up conspicuously in the signal-box. There are also the block instruments, one up and one down, at each end of the box, and similar instruments for each diverging line. Then there are telegraph and telephone instruments in considerable array, as circumstances require.

The frame is probably, if large - say 250 or more levers—divided into three sections, allotted respectively to a first, second, and third lever man; there will probably be two assistant lever men or signalmen, and two boys to attend to the telephone; with one chief man in complete charge of the box, who paces or patrols the bridge of signals, keeping watch on the actual movements of the trains below him, and giving any instructions he deems necessary from time to time. He is commonly known as the bridgeman. This organisation represents a staff of eight men on duty for one shift at this signal box, and probably twenty-two men for the 24 hours (one or two men less can manage the work in the slacker midnight hours).

A signal-box of this kind with a bridgeman in control is very different from the ordinary wayside signal-box which passes or admits train by train into and out of a block section largely in routine manner. In such a large signal-box as described the block system is to a large extent superseded (by special exemption which has been or must be obtained from the Ministry of Transport) and the safety of trains is secured by a sharp look-out, aided by careful interlocking of the highly complex concentration of signals and junction points inevitably connected with such station working. At a signal-box at a terminal station the block signalling of the trains in different directions originates at this box; and the station working as a whole is very largely dependent upon its efficient administration.

CHAPTER IV

THE SIGNALMAN'S CONTROL

THE consideration of the duties of a signalman from the point of view of train control requires that we should at the very outset understand the meaning of the block system, which for many years has been regarded as the key to safe working of trains on the British railway systems.

Stated succinctly, the principle of the block system is that only one train shall be admitted into one section of a running line at one and the same time; and the block signalling regulations are the code of instructions by which this principle of safety in working is given effect to. It requires that running lines shall be split up into a large number of continuous and contiguous sections, each of which is known as a *block section*, and the entry into which is controlled by a signalman, located in a signal-box, and communicating by special electric dial instrument with the signal-box on either side of him. Permission has then to be obtained by every approaching train from the man in the signal-box, before the driver of it may " enter the section."

The block system of train signalling has been compulsory on all railways on which passenger trains are run since the passage of the Regulation of Railways Act 1889, except under certain conditions, which will be subsequently referred to, where permission for exemption has been given by the Board of Trade (now the Ministry of Transport).

In the early days of railway working one train was allowed to follow another after a certain interval of time, the driver of each train keeping a sharp look-out so as to avoid running into any obstacle or obstruction in front. As trains became more frequent on the railway systems it soon became evident that this time interval as a method of ensuring that trains, often travelling at fast speeds, did not overtake one another, was inadequate, and from 1860 onwards there has been a growing feeling that some mechanical arrangement by which a minimum *distance* interval is secured between succeeding trains provides a more satisfactory and safer guarantee against accident or collision.

The system of block working in general operation in Great Britain is that known as "normally blocked" or "normally at danger" (as opposed to "normally clear"), though there is one important exception to this rule.* Under the general system of "normally blocked" no engine-driver is allowed to enter a block section of any railway with his train until he has first obtained a positive permission to proceed from the signalman who controls the section. This permission is obtained by the lowering of a semaphore signal arm (to indicate "line clear"), all the signals along the route being kept normally at "danger," except on the approach of a train. On a Sunday, for instance, on a railway branch where there is no traffic moving, or at night time after the last train has "cleared," all the signals are kept *on*, i.e. at danger, and if by any chance a special train were required to pass along the line, all the signalmen would first have to be brought back to duty to open the line.

In the case of the converse system, the "normally clear," a railway line would have all its signals off, and it would be open to any train to enter the various sections, unless the driver found some signal against him, to check his progress and bring his train to a stand. The "normally blocked" system is considered to be the safer system, because of the *positive indication* of safety that is provided for the driver, and, as has been said, it is the one which is generally in operation, and is sometimes spoken of in technical circles as the "affirmative" system.

It is important to bear in mind the two systems, as it has lately been found that the system—"normally blocked"—which is in general operation in Great Britain becomes somewhat cumbersome and difficult in the case of urban and suburban traffic of great density, as we shall hereafter explain; and the "normally blocked" system has become extravagantly costly * in recent years, since the absolute limit of eight hours to the signalman's shift of daily service has become established.

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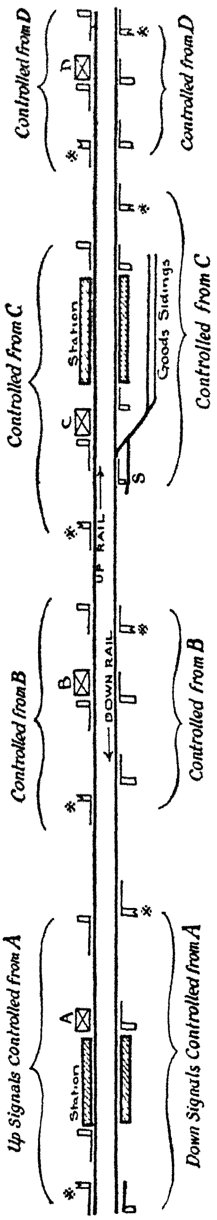
* This exception is the case of the London Electric and Underground Railways referred to in Chapter XV, p. 62.

The following diagram sets out the normal arrangements for working a portion of railway line under the block system as in operation to-day. It will be seen that there are set out three successive sections A–B, B–C, C–D, between the four signal-boxes A, B, C, D. At each signal-box, i.e. at the entry into each successive section, there are three semaphore signals, named respectively the *distant* signal, the *home* signal and the *advance* or *starter* signal. The real control or stop signal is the home board, and when this board is at "danger" a driver must stop his train before he reaches it. Under no circumstances, except under special arrangement in the case of accident or emergency, must a driver pass a home signal at danger. The



* *The distant Signal thus in all cases is placed about half a mile in advance of the Signal-box. S. = Advance Starter or Starting Signal.*

FIG. 4.—NORMAL ARRANGEMENT OF SIGNALS AT FOUR SUCCESSIVE SIGNAL-BOXES.

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* Before the Rates Advisory Committee (November 11, 1920) the representative of the North British Company stated that whereas before the war many signal-boxes were open for a shift of 12 hours, worked by one man at wages of 21s. to 23s. per week, the alteration in hours and wages necessitated the employment of two men each at 70s. 6d. per week, so that the cost of the box under the new conditions was more than six times what it was pre-war. The Government returns show the amount of wages paid to signalmen and gatemen in Great Britain in 1913 as £2,414,416; in 1924 £5,933,737; the increase on many of the country lines, if taken by itself, would show in considerably greater proportion.

distant board is a warning signal; when it is at danger the driver must be prepared to stop at the home signal; when the distant signal is down, indicating "line clear," the driver knows that the section ahead is clear for a straight run forward. The distant signal does not therefore bring the driver to a stand—he may run past it, reducing his speed so as to stop at the home board if necessary. The use of these two signals, the home board as the stop signal, and the distant as a warning, or repeater, telling the driver in advance what is the position of the home board, taken together are calculated to give the driver full confidence in running, as they indicate to him very positively whether there is any obstruction, or anything to prevent his going "full steam ahead" into the section in front of him. The distant board will always be on against the driver when the home board is at danger.

The third signal is the advance or starter; its function is, after a train has stopped at a station, very often having already passed the home signal post, to indicate that all is clear for it to move forward again; if there is a siding at the station, e.g. going into the goods station, the starter would be placed, if possible, in such a position as would give it control over the siding points. If these points were too far in advance of the station, a second signal—the fourth of the series at the entrance to the section in advance—might have to be arranged; this would then be known as the "advance starter." An illustration of this is shown on the diagram at Station C.

Now let us consider how the signalman in charge manipulates his signals. Take first a train running between A and B, approaching the signal-box at the latter station. Signalman B, having been informed by A that an express passenger train has passed his box, immediately asks C by electric indication, "Is the section B–C clear for the train to come forward?"; if B–C *is* clear (this must be carefully ascertained by B, particularly the fact as to whether the last preceding train has passed C box), B answers, "Yes. Section is clear for express passenger train to come forward," and on this assurance being received by B signalman, he then takes off his signals—starter, home, and distant. They must be taken off in this order, for, as a matter of fact, until the home board is taken off, the distant board will not come down; the interlocking of the levers prevents this mechanically; this interlocking is a cardinal requirement for safe working, and is decreed by Government.

The driver of the train thus finds all signals off for him, and as he passes B station the signalman informs C signalman of the fact of his approach, C inquires if the section C-D is clear for admission of the train, and if so takes off his signals, and so the process is continuously repeated as the train progresses from section to section. The average length of a block section may be taken as about 2 or 2½ miles in the open country; but where the density of traffic becomes at all heavy, the length of section is much reduced. On the Underground Railway in London, where at certain busy points as many as forty trains follow one another in one direction in an hour, the sections are, in some cases, reduced to about 400 yards, and the *average* length will not exceed 1 mile.

Now we must look at this operation from inside the signal-box, and see how the indications referred to are signalled from cabin to cabin. This is done by a particular description of telegraph instrument, which can only indicate three words or phrases on the instrument, namely: "Line Clear," "Train on Line," or "Line Closed." Normally the indicator hangs vertically, pointing to "Line Closed," but when a train has been accepted "Line Clear" is given as indication at both ends of the section so described. An illustration is given (Fig. 5) of an ordinary dial block signal telegraph instrument of the type commonly in use—the needle is deflected to right or left, as the handle at the lower part of the instrument is similarly turned. By the side of the instrument is placed a bell gong, which serves either as a call to attention or a signal indication, for there is a code of bell signals, as explained below, as well as a code of signals for the instruments. Either bell or dial needle can be used for the transmission of signals, in accordance with the instructions. The illustration shows a combined instrument for up and down lines. Often separate instruments are used for the two separate directions.

It should be added, as regards the dial instrument, that the two instruments for each line at the two ends of a section A–B, B–C, and so on, have their needles electrically controlled to work in unison, so that when B moves his needle from normal to either side, the needle of the instrument at A moves in exact unison.

The dial indications may now be described. As soon as a train passes the block post A, and is on its way to B, signalman B indicates to C by bell signal that a train is approaching. This he does as in manner following: first one beat of the bell as a call-up signal: this C repeats with one beat as an acknowledgment. Then B follows, on the bell code, with a query "Is line clear for a . . . train?" Assume it be a stopping passenger train, the code signal will be 3 pause 1 (= is line clear for a stopping passenger train?). If the line is clear (and it is C's business to assure himself that there is no obstruction of any kind), he accepts the train by a repetition of B's call on the bell code—3 pause 1. B then moves over the dial needle to "line clear" and C pegs the needle in this position, so that the visual indication is in front of each man that the line has been declared clear, until the train has passed C's box. B, having received the assurance from C that the section B–C is clear for the train, then takes off all his signals, which indicate to the driver of the train that he has a clear road.

The next stage in this signal operation is when the train passes B's box; as soon as this occurs, and the train has proceeded 400 yards into the next section, B rings up C with two beats on the bell, to indicate that the train has entered and is proceeding forward in section B–C. This is known as "train entering section" signal. C is, of course, on the *qui vive* for this signal, and immediately repeats it (two beats on the bell) to B. He, C, then sends on to D the signal "Is line clear for a stopping passenger train?" (3 pause 1), in the same way as we saw B send the signal to C, and the process is repeated from box to box. As soon as B has sent forward the "train entering section" signal, or, in the case of a stopping train, as soon as the train (the rear guard's van of the train) has passed the signals, he—the signalman—restores the semaphore signals to their normal position, and at the same time he gives the signal "train cleared section" by one ring on the bell to A. This completes the series of signals, everything is restored to normal, and the signalman awaits notice of the next approaching train.

We have only indicated here the main operations, and the standard important signal indications by which a train is signalled forward under the block system. It will be understood that there are many complications and subsidiary signals that are not referred to above, for the development of the code for practical use is complex, and the practical application of the principles above set out needs to be learned by experience on the railway system. As illustrations of some of the more important subsidiary signal indications may be mentioned :

1. *The "Stop and Examine" Signal.*—If the signalman sees or is informed that anything is wrong with a passing train as, for instance, he sees a carriage door open, he must at once send the "stop and examine" signal (seven sharp beats on the bell) to the next box, so that the signalman in the latter can stop the train and arrange to have the defect adjusted.

2. *Blocking Back.*—Whenever at a station or block post the railway lines are temporarily obstructed, say an engine comes out of a private siding to do some shunting, or a wagon in the goods yard has to be taken across the main line, the signalman before permitting this obstruction on the running lines is required to inform the signal-boxes on both sides of him—that is if both up and down lines are fouled—of the obstruction. A special signal indication is laid down in the code for this "blocking back" operation.

3. *Section Clear to Home Signal Only.*—This signal indication (3 pause 5 pause 5) is provided to allow of a goods train going forward at caution into a block section when it is known that at the station at the far end of the section a passenger train may be standing, or shunting operations may be in progress on the main line. A passenger train following would be held back a whole block section, but a goods train is allowed to proceed under careful regulation, being first stopped and told to go cautiously by the signalman in the rear section-box, as far as the next signal-box or stop signal. Careful provision for this permission being given to a goods train is set out in the block regulations.

In Appendix I is set out at length the code of bell signals which is in general use on the railways of the United Kingdom.

The semaphore signal boards exhibited along the railway for the guidance of the drivers are operated by levers fixed in each signal-cabin, and the principal mechanism within the cabin, or signal-box as it is now usually called, are the signal levers, fixed uprightly in a frame conveniently for the signalman to operate. This signal frame comprises the most conspicuous equipment in a signal-cabin.

We may add here a few words as to the position of the semaphores. It will be understood how important it is that the semaphore signals should be so placed as to be well seen, and this is largely dependent upon the background. The distant signal, being the first which the driver sees, should have special attention in this connection. Such signals should never be placed low down by the side of an overshadowing wood, for instance. On the other hand, a sky background is usually as good as any, if that can be secured.

The home signal is usually either just in front or just in the rear of the signal-box ; the distant signal should be from 500 to 800 yards in advance of the home board. As to the exact distance, much depends on the gradient of the line, as the signal is approached. There must be ample space between home and distant for the driver of a heavy goods or mineral train, or the driver of a fast passenger train, travelling perhaps 70 or more miles per hour, to stop his train before reaching the home board. A heavy goods train going 20 miles an hour down a severe grade may easily require 600 or 700 yards in which to pull up, and more than that if the rails are wet and greasy. On the other hand, if there is a rising grade as the signal is approached, 500 yards may be more thans ufficient, for as soon as the driver shuts off steam, a gradient of 1 in 150, or less, itself acts as a powerful brake.

We explain in Chapter VI the principle of interlocking and we have described the operation of the block system. The safe working of trains under the block system depends upon the signalman's reliability: there is nothing mechanical or electrical to prevent a signalman accepting a train and taking off his semaphore signals to allow it to come forward when the section it is to enter is still occupied, if the man himself is not reliable. But though accidents seldom happen from this circumstance, much thought has been expended upon finding some satisfactory means of locking signals so that they could not be taken off as long as the section they control was obstructed in any way. What is known as the system of "lock and block" (first introduced in England about 1872 by Mr. J. W. Sykes) is a method of locking the controlling signals at danger so long as the block instrument dial in the signal-box (see diagram) shows that the section is not clear. Such an arrangement prevents a signalman taking off his signal at the entrance to a section and sending a train away unless his code signal on the block instrument has been accepted by the signalman at the next box ahead, and this provides a certain measure of additional safety. There are, however, technical objections to this lock and block system, and several of the railway companies have declined to adopt it, alleging that it introduces an element of risk which is probably as objectionable as that which it was intended to cure.

Exemption from the obligation to provide the block system on passenger lines is given by the Ministry of Transport under two separate conditions :

1. In cases where the railway company is prepared to give an undertaking that never more than one engine or motor vehicle (or two or more such engines or vehicles coupled together) are on the section of line in respect of which such exemption is granted, at the same time ; and
2. At the approaches to, and within the area of, busy stations, where great concentration of traffic and trains occurs, and where the working is under the direct eye of the station officials. This latter exemption is a matter of necessity, if the complex and intricate train movements which so much traffic requires are to be got through at all.

In the case of exemptions under condition (1), the requirement of one train only using the section at one time is, in most cases, secured by the use of a staff or tablet, which acts as a key to the line. This is dealt with fully in the next chapter, dealing with single line working.

It has been already stated that, subject to the exemptions referred to, the provision of block system working is required by parliamentary enactment wherever passenger trains are worked. This is under the Regulation of Railways Act, 1889. For many years prior to that date returns were required to be made every year to the Board of Trade by each railway company of the mileage of lines opened for passenger traffic (single and double line respectively), and an exact measurement of the length of lines on which the block system had and had not been installed. By this means the pressure of public opinion was brought to bear, until the majority of railway lines in Great Britain were put under the block system method of working, and then, in 1889, Parliament made the installation obligatory so far as passenger train working was concerned.

It is worthy of note, as a matter of history, that during the parliamentary enquiry that led up to the 1889 Act, one of the leading railway engineers in England (Mr. T. E. Harrison, of the North Eastern Railway) gave evidence in opposition to any obligatory introduction of the system, because of what he considered were disadvantages and dangers inherent in the system. He held that the prevalence of the theory that the block system was a method by which absolute safety could be secured itself produced a new source of danger. His view was that it produced a feeling of false security in the minds of engine-drivers, officials and other servants, and that, gradually becoming reliant upon the semaphore signals, they would consequently be not so well prepared, as under other circumstances, to act on their own resources in cases of emergency or accident.

One of the minor but very useful devices in a signal-cabin is that of the signal " repeater " : this is simply a miniature semaphore indication in the cabin in a small case or frame, which is connected by an electric wire with the working semaphore on the ground and repeats, in miniature within the cabin, the position of the signal itself as it is in the open. The signalman thus has a visual indication before his eyes of the position of the signal, and can see whether the signal arm has really come off or on in response to his lever movement. Very often a distant signal is so far from the cabin, especially when the line is on a curve, that it cannot be seen by the signalman in his cabin, and it is in such cases that the " repeat signal " or repeater is employed.

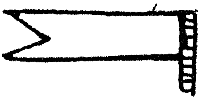
It will hardly be denied that the block system has very considerably reduced the responsibility and the anxiety of engine-drivers, and (as already pointed out) has given them much greater confidence in running. It does not follow in the least that the watchfulness of the driver has been reduced: evidence would probably point in quite a different direction, but the caution to which Mr. Harrison drew attention as necessary is worthy of note.

This chapter upon the block system may be suitably concluded by a recapitulation of the definition which we have relied upon and by a rehearsal of the names and functions of the four semaphore signals, which form the real control indications for the driver.

The block system of train control is a system for providing an adequate interval of space between following trains, and, in the case of junctions, between crossing or converging trains. This is secured by dividing the railway system up into a number of comparatively small sections, and enacting that never more than one train shall be in one and the same section at one time.

The following definitions refer to the semaphore boards made use of:

Distant Signal.—A caution signal, the first signal at which the driver arrives in approaching a signal post at the entrance to a new section, distinguished by a swallow-tail or fish-tail cut at the end of the semaphore arm, as illustrated in the margin. When the distant signal is up, or at danger, as here indicated, the driver must be prepared to stop at the home board: if the distant signal is down, it is an indication to the driver that he may go ahead without check, as the section immediately in advance is quite clear, and the home and advance boards (and the advance starter, if such exists) will also be down.



Home Signal.—The controlling signal at a block post, indicating, when at danger, that the driver must stop his train. It is usually placed immediately to the rear of the signal box or siding points. It is at the peril of his position in the service that a driver passes a home board at danger.

Starter or Advance Signal.—A stop signal, usually placed at the advance end of a station platform, to give the signalman control over the train after it has passed the home board. It is commonly used to signal a train forward after stopping at a station, or to allow a goods train to come out of the station siding.

Advance Starter.—A stop signal usually for use to control a train coming out of a siding, or through the station cross-over, when such siding or cross-over points are in advance, and therefore not under the control of the starter signal. (This signal is only provided where the station siding points are an unusual distance in advance of the signal-box, or where there is some other peculiarity in station construction.)

CHAPTER V

POWER SIGNALLING

We have now seen how the telephone has worked itself by degrees into the very warp and woof of the daily administration of train working and control, but we shall have much more yet to record of the remarkable developments, especially in train control, that would never have been possible had not the telephone provided the facility of communication and conversation between officers and servants engaged in a common enterprise at wide intervals and almost to the annihilation of distance. But the marvels of the electric current have provided assistance to human control in many ways, and one of these is its application in the operation of signals as an assistance to the signalman in moving the levers of points and signals. Whereas in the past the signals and points have been pulled over or released and set back by means of wires and rods operated by human physical labour, in all modern signal-cabins where there is a great concentration of traffic involving a complex frame of levers in a signal-box, the power for the movement of the levers is transmitted by electric current, the application of the current being through a switch as easy to operate as the push of an electric bell. The signalman's manual effort is entirely superseded and his mental energies are freed for concentration upon higher aspects of his work. The complications of interlocking in the signal-box are much more easily grappled with, and three or four or more movements (e.g. locking bar points, bolt lock and signals) can all be operated by one switch, which under manual operation would be in no way possible. One electric switch in place of three manual levers : again a great saving of human labour.

Safety devices, too, are much more effective, and in pulling over a pair of junction switch points the connection between the switch in the signal-box and the points on the ground is so complete that the switch handle will not " go home " (i.e. it will only come half over) unless the points are securely over and set for the required direction. The switch operating the points is indeed its own detector.

We have not, however, hitherto referred to " detectors " ; so this will be a convenient place to explain the technical meaning of such a device. When junction points are pulled over, whether at running junctions or in connection with sidings communicating with main lines, it is of the greatest importance for the signalman to know that the points are really over, and an electric " detector " is employed which indicates to the signalman that there is no breakage or defect in the point switches, but that they have come over and set the junction all right for the oncoming train or engine. These detectors are in various forms: one of the simplest is a needle indicator which points to " junction line in true position," when the points are rightly and securely set, just in the same way as the electric repeater in the signal-cabin informs the signalman when a distant signal which is out of his direct vision has gone down (see page 54).

Detectors of this kind can be used for various purposes to indicate to the signalman the position of points, signals, locking bars, etc. There is no need here to explain the technicalities of this device : we would merely emphasise how much more simple is the detector indication in the case of electric power signalling than in the case of manually operated levers. The operation of pulling over an electric switch to bring over a pair of siding points, as compared with pulling over a manually operated lever, is indicated in the diagram (Fig. 6). When the points are normally shut giving a clear set direction for the running line the switch is in the position A. When the siding points are to be opened the switch has to be pulled over the quadrant to the position shown at B. If the points do not come over and fit properly and securely for the siding junction (which eventuality would probably lead to a derailment of locomotive or vehicle), the signalman finds that he cannot get his electric switch over : it refuses to come over beyond the position C shown in diagram. Indeed, the pulling over of every switch practically is a dual operation from A to B through the position C. The switch having come over to the C position hesitates—only momentarily whilst the signal falls or the points come over, and when the latter operation is completed securely the switch completes its circuit. So with every movement the signalman is assured "signal moved quite rightly" or "points over securely," and this is a very important adjunct and contribution to security and efficiency in control. It is the application of electric power which gives this simplification and additional efficiency in the matter of detection.

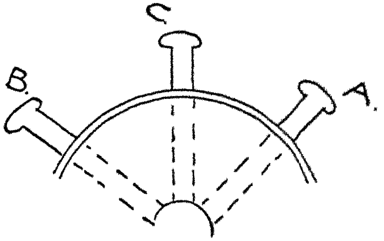


FIG. 6.—SWITCH FOR POWER SIGNALLING.

A. Normal position of switch for straight running line.
B. Position of switch when siding or junction points are securely over.
C. Intermediate position where switch stays until points are completely over.

But now we must at once come to the description of a power signal-box. The main difference in outward appearance is that the long, heavy, and cumbersome levers working in a frame raised just above the floor of the signal-box are replaced with a frame about the height of a table or a piano keyboard, and the small switches moved with a finger take the place of the tall levers.

The electric power frame goes into much smaller compass, so that the signal-box will be reduced in size to about one-third of the manually operated box which it supersedes.

Anyone who is acquainted with a signal-box at a busy point of concentration—say at any of our large terminal stations or junctions in London—will have no difficulty in realising the advantage to the signalman when he has his switches so much closer together: he will be saved miles of walking on every shift. Indeed, many signal-boxes requiring three men as manual boxes could be worked with two as power cabins and give to each of the two a much easier post than hitherto each of the three men had. This reduction in size of cabin and the additional ease of operation are the main advantages attributable to the power operated cabin: but there are several others. With electrically operated boxes the power is transmitted to the points or signals by underground wire instead of surface rodding or wiring, and thereby much valuable surface area is saved at places where every square yard of space is precious. Electric current can operate points or signals at practically any distance, and as securely 600 or 700 yards away as at 60 or 70. This has led to a relaxation of the Ministry of Transport restriction, which provided that facing points must not be operated at a greater distance than 300 yards from a signal-box, and trailing points not more than 350, to allow of 350 yards (or in many circumstances even more than that) in the case of facing points and practically at any distance for trailing points. We may give here two illustrations to show how this works out in practice. Firstly, in the case of a relief, running, or refuge siding of 800 yards' length: under a manually worked system two signal-boxes (A at one end and B at the other) would be essential, whilst there would be no difficulty under a power system in working both sets of points from a signal-box at C placed half-way between A and B, or even from A alone, the box at B being abolished; for the trailing points at B could be quite easily and conveniently operated by A.

A second case is that of a triangular junction, of which there are many up and down the country, arranged as shown in the diagram (Fig. 7), where under manual working three signal-boxes are required. Under electrically operated signals and points one box placed in an intermediate position could easily control all three junctions. The three signal boxes A, B, and C respectively could be abolished and a box placed in the centre as at D instead. The saving of labour and wages in a case such as this will, of course, be very considerable.

To sum up the advantages, a power operated signal-box takes less room as regards site, has a smaller internal frame which saves the signalmen much walking about during the day, abolishes all manual effort in its simplicity of switch movement, and is much more efficient in interlocking all necessary points and signal movements and in detecting any flaws or defects in the points or switches. Much valuable ground space is saved by the elimination of rodding and wires on the surface.

We have assumed above that the power used for signal-cabin operation is electric. As a matter of fact, in Great Britain the power most commonly employed is the dual arrangement known as electro-pneumatic, the operation of the signals or switch points being by means of a small pneumatic piston and cylinder the movement of which is effected by electric current liberated by the switch in the signal-box. There are, however, cases where the power is electric throughout, the current being conveyed by wire from the signal-box, and the points or signals being then operated by a small motor on the spot.

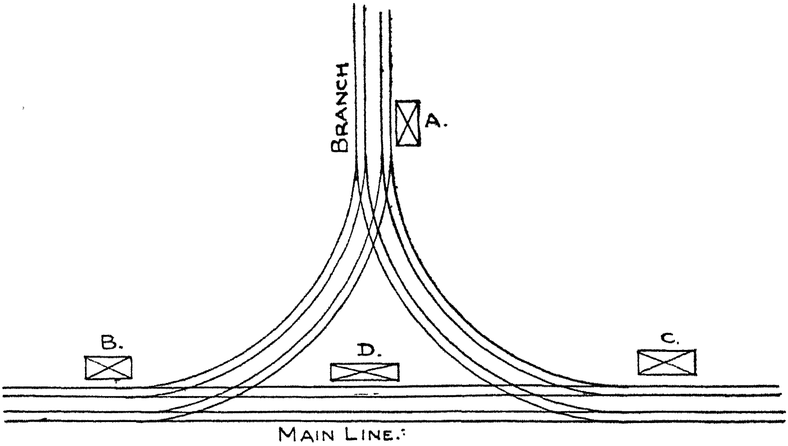


FIG. 7.—DIAGRAM OF TRIANGULAR JUNCTION.

Pneumatic power alone may also be used and is so used both for transmission and operation in certain countries on the Continent: but for British practice the electric current or electro-pneumatic operation has advantages which as yet have been held to leave nothing in favour of entirely pneumatic control.

Having described the system of power signalling whereby the signalman is provided with the necessary electric power from outside in place of his own physical effort for practically all his work, it would seem a natural sequence that we should next describe the method of automatic signalling by which the need for a signalman is practically eliminated *in toto*, the train signalling itself automatically as it pursues its journey. It is easy so to manipulate the electric current by a system of "track circuiting" that whenever a train is travelling along a pair of rails the wheels of the train themselves by connecting up the two rails produce what is technically known as a "short circuit," and this sets in motion mechanical arrangements which lock the signals behind the train at danger until it has proceeded a certain distance in advance. Thus the train automatically secures for itself safety against the possibility of following trains overtaking it in the rear, but under the British system of signals kept normally at danger a train controlling its own signals first requires the signals to be taken off in front of it. This is the arrangement which is in regular working operation for some 10 miles on the main East Coast line to Scotland on the L. & N.E. Railway between Alne and Thirsk, a little north of York. When this system was installed some years ago, some seventeen or eighteen sections were substituted for six or seven under the previously existing manual block working giving a considerably greater capacity to this section of line for holding trains, and at most of the signal-cabins the signalmen were withdrawn. As a train comes along it automatically by track circuit lowers the signals in front, unless some other train be occupying the section, when, as already indicated, that preceding train has electrically locked its signals at danger, preventing any oncoming train taking the semaphores off. Here we have a system of automatic signalling applied to block working under the British conditions of "normally blocked."

This case on the (old) N.E.R. is one of a few experimental installations which have been made under British conditions. There are several others, but they are of short distance only and none of them on any extensive scale.

The best illustration we have in England of automatic signalling is that on the London Electric Railways (Underground and Tube), and here the usual British practice of "normally at danger" or "normally blocked" is reversed and the basis of the whole system is "normally clear."

It will be easily understood that where a system of "normally clear" can without disadvantage be adopted it is free from complications which are inherent in a "normally at danger" system when automatic signalling comes to be adopted. The engine man as he comes along assumes the line clear, and is confirmed in this as he comes to each signal, unless a train is in the section immediately ahead, when the green signal (all clear) is taken off and locked to show red (danger). Most of the objections to a "normally clear" system are non-existent as applied to the London Tube Railways: the track, being in tunnel and far below the surface, is freed from the possibility of special obstruction by trespassers doing damage to the rails; there are no level crossing gates, and the line is free from siding points at the stations. Automatic signalling is, therefore, comparatively easy of application to the Underground and Tube systems, and has been very effectively and very thoroughly carried out over about 72 miles of electric railway track in London.

The control of the London Electric Railways is so effective and efficient by this system of automatic signalling and other devices that it may be well to describe in some further detail the various devices employed, these devices in themselves being a very distinct and definite contribution to the general question of train control in Great Britain. In Chapter VI are set out particulars of many of these devices, whilst Chapter XV deals specifically with "Control on the Underground."

Automatic train signalling has, it may be here pointed out, been carried considerably further in America than in Great Britain, the returns showing that out of 226,837 miles of passenger railway track in the States, some 40,000 miles are operated under automatic block signalling. On the other hand, of the 226,000 miles only 102,468 miles—less than half the system—is worked under block signalling arrangements.

This would seem to suggest that in some respects American train signalling is in advance of Great Britain, in others distinctly behind.

CHAPTER VI

SUBSIDIARY MECHANICAL DEVICES AIDING CONTROL

WHILST in so many ways improved appliances and mechanisms have of recent years been introduced to secure safer and more efficient working on our main lines, many subsidiary devices have also come into use to assist the pointsman—or signalman as he is often called—who controls the working of a marshalling yard.

One or two of these devices which exist in the modern yards of Wath (Yorkshire) and Feltham (on the Southern Railway, near London) may first be referred to.

In both of these marshalling yards the control of the whole working of the sidings is from a tower or signal-cabin situated at the high end of the yard, on the top of the hump over which the shunting takes place—for both are gravity yards—and the points or junctions into which the various wagons are destined are worked and controlled from the tower.*

There are at Wath some 30 reception sidings, 15 on one side of the "switch street" or centre running lines, and 15 on the other side: the even numbers are on one side, the odds all on the other.

The points are all worked by electro-pneumatic mechanism direct from the tower, the indication of the siding required for each wagon or set of wagons being obtained by the towerman from the wagons (the number of siding wanted having been indicated by chalk mark on the wagon by the foreman). This method of working the marshalling yard by concentration of the levers, or rather electric switches, in one pointsman's tower is a great advance on the old style of loose points working by means of adjacent ground levers.

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* I am using the word "tower" for the pointsman's cabin, for it is really a pointsman's tower rather than a signal-cabin. No signalling in the proper sense is performed here.—*Author.*

At Feltham, the principle of concentration in one tower and the electro-pneumatic working is the same as at Wath; but the method of electric repetition of yard movements within the tower itself marks a great step forward. Within the tower, on a flat table, is a representation of the sidings points as they are on the field itself, and as the wagon moves down the sidings it reproduces itself automatically in miniature on the illuminated diagram, so that the pointsman may watch its progress along the yard sidings, even at night or during a dense fog, and he can see for himself when the wagon, or wagons, have cleared the running points into their appropriate siding, and the line is again all right for the next wagon to follow.

Just as, as described in Chapter IV, small electric repeaters are fixed in a signal-box to indicate whether a semaphore distant arm has come off properly in response to the lever when the signal post itself is out of view of the signal-box, so, in the case of the marshalling yard towerman, as the actual passage of wagon after wagon over the siding points in the railway yard is too far away from the towerman for him to see accurately, or it may be obscured by fog, the repeating or recording instrument in the tower—a miniature replica of the actual sidings and points on the ground—is of the greatest value and assistance, and relieves him of much straining of sight and worrying calculation.

In the United States this method of repetition within the signal-box by mechanical reproduction and illuminated diagrams of the station yard around the signal-box is of much more extended application than we have it in this country.

The Regulation of Railways Act, 1889, which provided for the general establishment of the block system on railways open for the public conveyance of passengers, gave to the Board of Trade, at the same time, power to order the railways to provide for the interlocking of points and signals.* We must explain the meaning of this parliamentary provision.

We have already referred to the fact that when the home signal is at danger the distant signal must be in the same position: it is secured in this position by mechanical locking; that is to say, whenever the home board is "on" against a train, by a simple notch arrangement or by some other device in connection with the two levers in the signal-box, the lever controlling the distant signal cannot be taken off; it is mechanically locked on, and can only be released when the home signal lever is pulled over to take off that signal. This is a very simple illustration of what is meant by the interlocking of signals.

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* It also made compulsory the provision of efficient brakes on all passenger trains, see Chapter VIII, p. 84.

Similar locking and interlocking arrangements exist in connection with siding and junction points. Consider the simplest form of an ordinary running double-line junction (see Fig. 8, page 67). To the uninitiated observer, it would appear that perhaps the most risky cause or point of accident would be the "fouling point," where a train passing along the direct straight line from A to B crosses the track of another train travelling from C to A, that is to say, at the point E in the angle or point of divergence of the junction rails. But by a very simple locking device such a cause of accident is ruled out altogether. Whenever the line is set for a train to run through the junction from C to A, the points at the junction in the opposite direction are also set for the same direction, i.e. for the branch line, and they are so locked. Thus, if, as the train from C was running through the junction at E, another train destined for the straight line from A to B overran its signals at D, it would run, not to the fouling point at E, but into the branch line towards C: thus are the junction points interlocked. But more than that, the points are interlocked with signals, so that when the junction points are taken off for the branch line the signal which controls *any* train approaching the fouling point at E is mechanically locked, so that it will not come off. So there is this double precaution: first, when the junction is opened for the branch the signals are locked "on" against the approach of any other train, and, secondly, if the train were to overrun its forbidding signal it would only run into the branch line, and not into the fouling point at the junction. These illustrations indicate what is meant by locking and interlocking. Points are locked to prevent fouling at a point of convergence: in the same way, signals are locked (or interlocked) with each

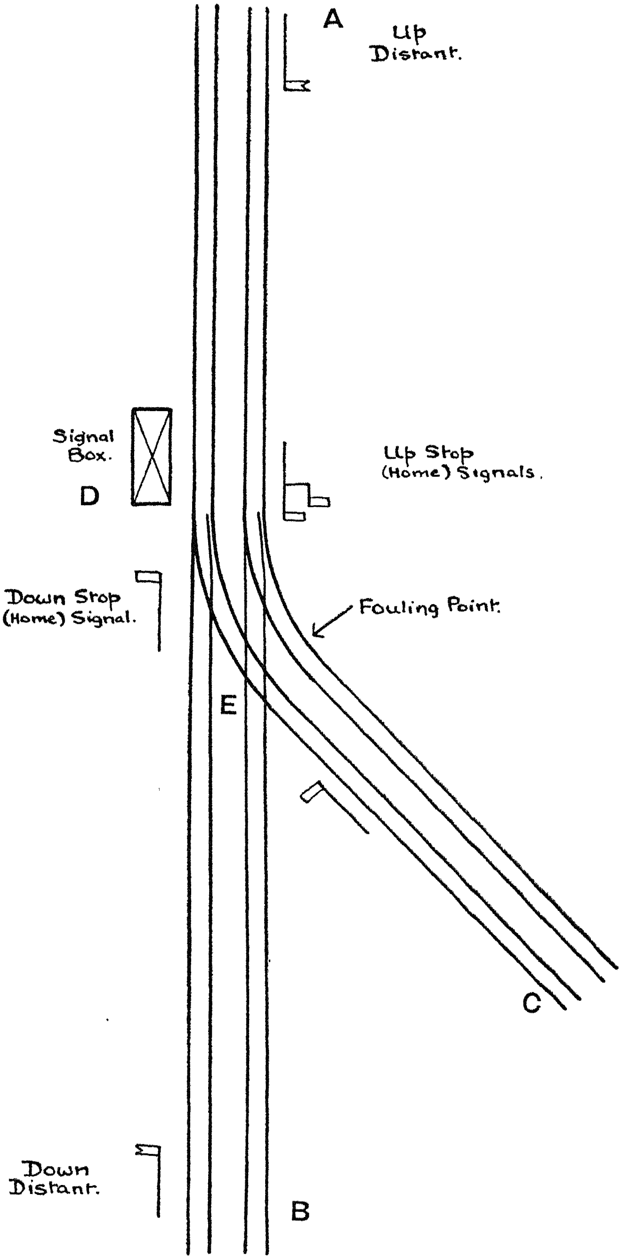

Fig. 8.—Diagram of Double Line Junction.

other to secure that two such shall not be "off" at the same time if they are signals controlling trains to a converging point; and, again, points are interlocked with their appropriate signals and so secure:

1. That the signal shall indicate that the line is clear for a train, and
2. That no other signal, the taking off of which might lead to collision, can be pulled off.

This interlocking of signals has many applications: for example, where a roadway with gates crosses the line on the level, whenever the gates are open to the road, and closed across the railway, signals against the train are provided; they must be at danger before the gates can be put across the railway, and the opening of the gates across the line locks, or interlocks, the signals at danger.

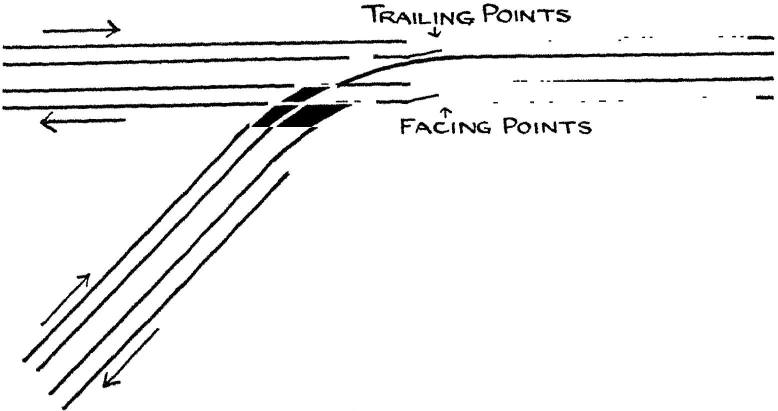

FIG. 9.—DIAGRAM OF FACING AND TRAILING POINTS.

Closely allied to this subject of the interlocking of points and signals is the provision of other safety appliances, such as (1) facing point locks, and (2) locking bars. At every ordinary double-line junction, one line has a pair of facing points, the other a pair of trailing points: the diagram (Fig. 9) above shows this.

It will be seen that the actual point heels or wedges are in the one case facing the direction in which the train is travelling, in the other they are the reverse, i.e. trailing. Hence these technical names. Before the days of locking and interlocking, facing points were a fruitful source of accident, especially derailing of vehicles ; for the thin end of the wedge would, by working loose, spring up between the successive vehicles, or wheels of the same vehicle, and then derailment would almost inevitably ensue. But now this cause of accident and derailment has been almost entirely eliminated, for whether the switches are set for the straight line or for a diverging branch line, the thin end of the long wedge is clamped against the rail with which it makes a junction, and is *locked* by an ingenious device, in the way of a bolt, which makes the junction, including the facing points, perfectly safe. The bolt lock is, in turn, locked with the signals, which control the junction.

The locking bar is used for various devices, but one of the principal of these is to prevent the signalmen changing the points between the front and rear wheels of the same vehicles, or between two succeeding vehicles, when a train is passing over the junction. This is very simply accomplished by a bar (40 or 50 feet long), which fits in, side by side with and close to, the outside of the rail. Before the points can be changed the locking bar must be pulled over by means of a lever in the signal-box and connecting rods. The locking bar cannot be moved when a train is passing over : and the effect of this is that, as the point levers are locked with the locking bar lever, they cannot be changed until the latter is first pulled over, but such pulling over of the locking bar lever is impossible whilst the train of vehicles is on the junction.

It will be realised, therefore, that before the facing points at any junction can be pulled over, various movements of levers are necessary on account of the locking. Before the direct signal board will come off, the signal controlling any converging line must be in the danger position ; the locking bar lever must be pulled, then the facing points, then the facing-point bolt lock, then the distant signal, and then the home board, and only in their right order will the levers come over. It is part of a signalman's training to become used to these operations, which often to an outside spectator appear very complex.

The more one studies this question of devices for locking and mechanical control of junctions and signals, the more one realises how difficult it is, rather than how easy, for the signalman, in all ordinary cases, to make such a mistake as will cause accident. He is protected in so many ways by automatic devices that the responsibility in this connection is far less than is usually credited to him by the lay mind.

It is different, however, with the driver ; he may overrun signals, and then accident is more likely than not to follow ; but, as will be explained later, more in detail, devices are now in existence (very extensively on the London tube railways) by which, if a driver overruns his signals by mischance, an automatic mechanism immediately springs into action, and, by releasing the engine brake at once and rapidly, brings the train to a stand.

Single Line Working.—The control of trains on single lines, and their regulation to avoid accident, is in itself a special study. All that we have written hitherto has, as will be recognised, had reference to normal double line working, where the up and down trains have each their separate tracks. Where the same track is used for both up and down trains special appliances and signals are necessary, as trains are moving on the same pair of rails in both directions. One might think that on account of the liability of trains in opposite directions to meet on the same track there was a special liability to accident of a serious nature. The facts of experience show otherwise : single line collisions are actually rarer than such occurrences on normal double lines, and the case of the collision at Abermule on the Cambrian Railway on January 26, 1921, was unique in its character. The general immunity from this class of accident is undoubtedly a direct result of the safety devices which have been adopted.

The principle adopted is simple and easy of understanding, although the method of application under circumstances which differ widely needs a good deal of consideration. In the first instance, in Great Britain most of our single line sections are short, and if they were to exceed, say, 10 or 12 miles, it is probable that they would be broken up into shorter sections by the provision of "passing places" where trains can pass one another under properly protected arrangements. In the great transcontinental line, which has been constructed from West to South Australia—1,000 miles from Calgoorlie to Port Augusta—there are single line stretches of 84 miles. We have nothing approaching the kind in Great Britain. In America there are also long stretches of single line. Out of a quarter of a million miles of railway in the U.S.A., nearly 90 per cent. are of single line.

The key to safety in single line working is that only one train shall occupy a single line section at one time; this is secured by the provision of a staff (or tablet) which acts as the key to the section, and no train may enter the section without first obtaining the staff from the signalman at the end of the section. A train can therefore only enter the single line from that end of the section where the staff happens to be at the moment; and therefore it has to be so arranged that trains will pass over the single line alternately in opposite directions to secure that the staff is always at the right end of the section for the driver to pick up. If a train, from some unexpected cause, requires to enter the section at the opposite end of the section from where the staff is for the moment located, there is no option but for the signalman who holds the staff to send it by foot-messenger, by bicycle, or by motor, or by whatever means he can secure to get it most expeditiously transferred to the other end where it is wanted. This makes the simple staff working a matter of some inconvenience, for it will sometimes happen that it is impracticable to obtain the necessary alternate up and down working of trains. The "*staff-and-ticket*" system was at an early date devised as a simple modification of the staff arrangement, to admit of two trains following along the single line in the same direction; and now, wherever the simple staff is in operation for single line working, it is supplemented with the ticket, under the arrangement explained in the next paragraph.

Staff and Ticket Working.—In order that a second, third, or additional train may succeed each other over the single line in the same direction before a train returns in the opposite direction to bring back the staff, a series of tickets is instituted —say six—to work in conjunction with the staff, to represent and do duty for the staff, as it were. The full charge and custody is with the signalman at the entrance of the section, and when he knows that, say, two more trains require to enter the section in the up direction before a down train will be coming, which could bring the staff back, he may allow the first and second trains to go forward with a ticket each; the ticket in that case becomes the authority, in place of the staff, for running over the single line. It is an invariable regulation, binding upon a driver, that he must satisfy himself, whenever he proceeds on the single line with a ticket, *that the staff is in the possession of the signalman* who issues the ticket. The tickets are really metal plates, marked with the name of the particular section to which they relate. If the staff itself is away from its home, i.e. either of the signal boxes at the end of the single line section to which it belongs, no ticket can be issued; this is made secure by the tickets (half a dozen metal tablets) being kept in a grooved box, to which box the staff is itself the key; when the staff is away, therefore, the tickets are locked in safe custody.

An illustration of the use and need of the ticket may be given. A cross-country piece of single line forms part of a direct route to a seaside watering-place, though not the usual route for ordinary trains. The normal working on the branch is only some half-dozen trains per day, and they are arranged for up and down journeys alternately; but on Saturdays and half-holidays in the summer the line is brought into requisition for the working of excursion trains to the seaside, and on these days of holiday three or four special trains are worked in succession over the single line, and the same number back at night, all of them independently of and in addition to the normal local service. Such a condition would require the issue of three or four tickets, one to each train, and the signalman at the entry into the section would show each driver the staff as he passed and hand to him a ticket, sending on the staff afterwards by the ordinary train as usual.

Although we have thus explained the principle and method of staff and ticket working, it must be added that it is really an out-of-date method, and we must regard it only as a stage in the development of single line working arrangements. In these days of electric science we might rather expect to find further assistance from this direction, as we do, and the electric staff (or tablet) has now quite superseded the old staff and ticket system as an efficient instrument, although the latter is still in operation on a great many single lines in the country.

Electric Staff or Tablet.—The principle of the electric staff is that when the staff, which (just as with the non-electric) after being taken through the section, is restored to its box or case, the section becomes automatically open for a train to enter at either end. The design is ingenious and simple. Instead of tickets, which may be issued as explained under the staff and ticket system, there are duplicate staves—as many as convenience in working dictates—and when a staff is taken out of the box all the others, at whichever end of the section they may be, are locked in, the electric application securing that both ends are locked, unless the full, normal number of staves are at home (i.e. in their boxes) at one end or the other.

Suppose, for example, there are 30 staves, starting with 15 at each end. When a train enters the section the signalman hands out a staff to the driver, and the issuance of that staff automatically so locks the case or box that no other can be taken out. When the staff is restored at the other end—there will then be 16 in one box and 14 in the other—another staff can be withdrawn at either end. There must be 30 staves in the two cases or boxes in order that one staff may be withdrawn; as soon as one is withdrawn a second will not come out, and the 29 must again be made up to 30 before the next can be taken out.

The receptacle in which the staves are enclosed—we have called it a staff case or box—is in reality an upright pillar-box, somewhat resembling in appearance an automatic supply instrument so often seen on railway-station platforms. See diagram, page 74.

The saving in worry and anxious calculation which this simple electric device has effected for the signalman in control of single line working is something enormous, and yet—so perverse is human nature—this improvement was only installed in face of strong opposition from the very men it was intended most to benefit. At the first installation of electric staff working on an important line in the writer's own experience the signalmen concerned protested they would never be able to make use of so complex a piece of mechanism, and when the local officer pressed upon them a sense of their duty to try, they carried their resistance to the point of leaving their posts of duty rather than obey superior orders. A relief staff were substituted for the time being, who worked the instrument satisfactorily, and ultimately explained to the absentee signalmen its advantages, after having demonstrated its practicability. The writer well remembers how, about a year later, when he questioned the men as to how they were progressing in the use of the new-fangled toy, they admitted they could hardly understand how they ever could have managed without it.

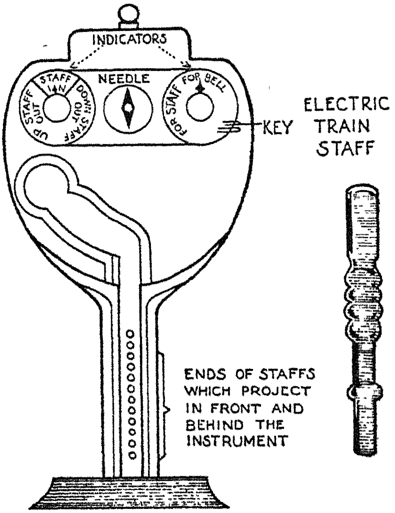

FIG. 10.—ELECTRIC TRAIN STAFF APPARATUS.

The operation of this system of electric staff or tablet gives effect to the same principle as the block system, as it secures that only one train can be in a given section at once; and therefore the expense of installation and upkeep of the block wires and instruments is, or may be, obviated. This, of course, must be taken into consideration of the extra cost of the electric staff apparatus.

We need not describe in any detail the electric *tablet*. The principle is precisely the same as that of the electric staff, the only difference being the shape of the two appliances, the staff and the tablet. The tablet and its custody box take less room than the staff pillar box; and it is contended that it is easier to exchange with the driver, this exchange having, at times, to be made when the engine is travelling, perhaps, from 10 to 15 miles an hour. For the purposes of this exchange the tablet is placed in a leather pouch, to which a wire ring or loop is attached as a handle. Every tablet or staff should have engraved or embossed upon it in clear and distinct lettering the name of the section of line to which it refers.

There are advocates for both the staff and the tablet, as being a superior instrument, but the arguments are about evenly in favour of each. As regards the tablet, injury to a driver has occurred, owing to the loop wire through which he had placed his arm swinging round and hitting him a very ugly thump on the head; but with care anything of this kind should be avoided.

The very extraordinary collision at Abermule referred to on page 70, which occurred on January 26, 1921, was due to improper tablet working. Seventeen lives were lost and thirty-six persons injured as the result of this accident: the circumstances were so unusual that they are worth recalling. Two trains, an up express from Aberystwith and a down stopping train from Whitchurch, were due to pass each other at Abermule, an ordinary passing place on the single line, where the tablets attaching to the two sections Newtown–Abermule and Abermule–Montgomery would normally be changed. The express was running a little late, and whilst it was approaching Abermule on the single line from Newtown—carrying the staff, of course—the station staff at Abermule sent away the slow train from their station, in the face of the approaching train, with the inevitable result of an end-on collision. The driver of the slow train, on arriving at Abermule, duly deposited his Montgomery–Abermule staff, and was, after waiting five minutes, sent forward *with the same staff*, which he had just deposited, relating to the section in his rear. The driver failed to see that he had the right staff relating to the section he was entering; it was handed to him by a relief station master, who in turn had received it from the boy porter—who had no authority to touch it or to deal with the tablet working; and the station master and signalman were both held by the reporting inspector to have neglected their duty of making sure that the tablets were rightly exchanged. So that altogether some half-dozen persons failed in their duty on this occasion, any one of whom might have obviated the accident, and *would* have obviated it, had he properly carried out his instructions. This circumstance is eloquent in regard to laxity of staff supervision at the particular station concerned, and is only mentioned here in illustration of the point that it usually requires more than one person to fail in duty to lead to serious accident, and that, however perfect the engineering mechanism, the element of human frailty or misjudgment is constantly behind and liable to nullify the best efforts of science to render serious catastrophe an impossibility.

These subsidiary devices in the control of the working of trains are direct benefits which have resulted from the progress of applied mechanical science and engineering as it has been brought to bear upon railway working and signalling equipment, but it has been found necessary to bring governmental authority to bear to bring all the railway companies into unison and to require the universal adoption of many of these devices which have been invented for the purpose of greater safety and greater efficiency.

CHAPTER VII

THE TELEPHONE AS A MEANS OF CONTROL

BEFORE embarking upon a description of the more advanced systems of train control which have become possible mainly through the efficient and extensive development of the telephone as a practical adjunct in train working, may we not well devote a little thought to the general question of telephonic development and its meaning? Do we not often fail to appreciate the vastness of the change that has come over our commercial, social, and mechanical world as the result of the telephone. The more complex is any organisation, the greater is the change introduced, although perhaps the more difficult to realise, for it is going on concurrently all around us, and we ourselves are in the midst, and an actual part of, the continuously changing world. *Tempora mutantur et nos mutamur in illis.*

For what the telephone has accomplished more than anything else is the quickening up of the speed at which thought travels. Let us consider, then, how it operates in a great railway organisation. And let us begin at the head offices. A general manager has a ruling to give by which the daily duties of thousands of people are affected. Before deciding various points on which the ruling depends, he needs to consult three or four officers—his engineer, superintendent, goods manager, accountant, and others. In the olden days the papers relating to the matter were put by until he met first one, then the second, then the third of his colleagues, and so on. Several weeks might elapse before he was in a position to decide the question and declare his ruling. Now, if the matter is urgent, he can speak over the 'phone to the three officers and decide in one day what formerly may have taken weeks to arrange.

This refers, of course, to the cases where personal conversation is necessary rather than correspondence.

Or let us put it another way. Some complicated scheme is to be taken in hand, the remodelling (say) of some large station involving perhaps the expenditure of hundreds of thousands of pounds. Preparatory work may go on for months, or perhaps two to three years, occupying the time of scores and scores of people, only to find after many months' labour some weighty objection on the part of one officer who had not been consulted, and the whole matter is hung up. With a telephone system an initial consultation may and will take place before any serious work is embarked upon, and any fundamental objection would at an early stage be discovered or removed. If not removed, then further preliminaries would never be embarked upon, and unnecessary labour would be saved.

When this principle of a quicker exchange of views between the principal actors is extended throughout all the transactions and communications that go to make up the current work in the offices of a railway system, we may form some idea of the marvellous acceleration which has taken place in the processes of administration which are constantly and continuously at work. The human mind is applied, and in co-operation, much more expeditiously and effectively in the settlement of the complex problems which form the daily routine of railway officers' work.

We may take another illustration applying in a rather different area. A goods agent in a certain town may to-day, by means of the telephone, get information from various traffic senders in the town as to the amount of traffic they desire to forward to-morrow, enabling him to plan his work, his wagons, and his train arrangements in a way hitherto impossible. A local superintendent may daily, and much oftener than the day, discuss over the 'phone, with all the principal station masters, the arrangements necessary for their train requirements, and so on.

In accident or emergency a local agent may at once consult his superintendent for advice and guidance, explaining to him all the circumstances in a way which would not be possible by correspondence ; and in various similar ways we may say the minds of the masters and the knowledge of the experts are being conveyed to those who need that knowledge and that assistance which it is the business and the true function of the master—the expert—to give.

A head signalman at an important junction station, instead of being in direct communication merely with the signalman at his next adjacent signal-boxes on either side, say, 3 or 4 miles distant, is now usually connected by telephone circuit, i.e. at large or important places, with signalmen 12 or 15 or more miles away, so that he can at any time find out the position of approaching trains over a much larger area than before. Here we have a beginning of the extended use of the telephone in train control.

In any head railway office a principal officer in a railway company will have on his desk a connecting 'phone on at least three, very likely four or five, telephone circuits. He will pick up one telephone to speak to any of his assistants in his own office, or colleagues in the same suite of offices; a second 'phone will bring him into contact with any of his brother officers or district officers in the same railway company's employ (by means of a private exchange and wires); thirdly, he has a connecting instrument to the Post Office telephone system, which puts him at once into communication with the world at large. Often he has other instruments for subsidiary purposes.

In the daily administration of at least one large railway company an item on the routine agenda of the general superintendent is that at ten o'clock every morning he has an interview with his divisional assistants, situated in different parts of England, and together they discuss (with but little less convenience than if they were sitting in the same room) any special features of the day's work before them or of yesterday's experience. This use of the 'phone vastly increases the effective influence which one man in authority can wield.

This adoption of the telephone on so wide a scale really alters the whole character of the supervision in a large industrial concern; the administrator has a much wider vision and a much more ready means of communicating and enforcing his orders, whilst the subordinate officers in their turn have a much more ready means of getting to know the mind of their chiefs as well as the general circumstances affecting their particular sphere of work. It cannot be denied, however, that the new development creates a much wider separation between master and servant; there is less of the "personal contact," whilst curiously enough intellectual contacts become greater and wider-reaching than ever. This transmission of intellect, thought, and sentiment is again vastly further quickened by wireless and its subsequent developments, though this agency has not yet become useful on the railway systems.

This factor will probably be better appreciated by consideration of it on parallel lines in a less complex department of life—that of domestic service. Compare the position and relation of mistress and servant in a small domestic establishment with those in the case of a large hotel, where supervision over the domestic side of the whole place, with its hundreds of servants, is carried on from a central office with adequate telephones, and where the servants are differentiated according to floors and varieties of service, each group being subject to intermediate supervisors, who are themselves connected by telephone wire to the office, and through whom all orders are received and all daily instructions pass. A great gap between individual servant and the administrative head is created, yet without this telephonic organisation a modern large hotel would be unmanageable. It is, indeed, the telephone which creates the possibility of a large hotel or large city stores or industrial establishment being successfully developed. But it also creates new problems of human relationships.

"New occasions teach new duties," and new duties call for new methods of administration: and as has already been pointed out when comparing the size of the L.M. & S. Railway with its largest constituent company prior to amalgamation, it by no means follows that a particular method or system which is fitted and quite apposite for the smaller number of miles is going to be equally successful when applied to the larger unit.

We may illustrate further this effect of the 'phone by reference to what is now being done by way of central control over the cartage arrangements of what was the old Midland Railway system in London. All the various carters or rullymen and their teams—there are some 800 or 900 horses—are under the control of a cartage superintendent, who has his control office at Somerstown (St. Pancras). The cartage area in London is divided into forty-three districts, each of which has a depôt and a number of teams normally located there, and, under the system of central control, the main object is, by co-ordination of the arrangements, to prevent overlapping, and so get the goods delivered or collected in as economical a manner as possible. The movements of every carter (or rullyman) are watched hour by hour, the time every man leaves his depôt and the time he gets back again being promptly transmitted by 'phone to the control office. When the carman leaves his base station in the morning he is entirely under the controller's instructions, and as soon as he has effected delivery of a load of goods he asks the controller for instructions as to his next call or round of work. The controller, having information from each depôt as to the work that is still on hand, can at once allocate to the carman his next turn. The control staff at Somerstown is not large; it consists of a chief controller and his assistant and six lady clerks. Two of the ladies are occupied with the 'phone, and the others are summarising the information they receive from the stations and depôts. Every day each man's work is summarised under the three heads: (1) total time worked; (2) total tonnage carted; (3) total mileage worked; and at the end of each month the aggregate and the daily average under these three heads is also ascertained.

The difference between a central control, co-ordinating the work of the various men at work in all these forty-three districts, and the older arrangement under which the twenty or thirty teams at the several depôts were each doing their best in their own immediate neighbourhood, may be imagined; much economy is the result of the co-ordination. The general efficiency of the arrangement and the mere knowledge on the part of each man that he is being carefully watched by the master's all-seeing eye has its very practical effect in improved service all round.

We may take one more illustration, that of the working of the motor-buses of the L.G.O.C., which is now similarly watched by a central control office; of these buses there are about 3,500 in daily working, and to get the right and economical distribution of these vehicles over the different lines along which they work is a matter of complexity, requiring constant attention, with an ingenious and resourceful mind in charge. Day by day it is found that one district will be overcrowded and have a shortage of buses, whilst another has room and to spare on its vehicles. Telephonic reports are systematically being received at a central office of how the buses are being loaded, as well as constant information from each terminal-point as to the extent to which the vehicles are arriving late or whether they are to time. With all this concentrated information at one point the controller gets to work to consider whether any re-arrangement in his scheme of things for to-morrow's work is necessary, in view of his accumulated experience of to-day and previous days under similar or varying circumstances.

Then comes the element of weather, which has a great effect on the bus services, especially on a Sunday in summer. If a heavy rainstorm comes on unexpectedly on a Sunday the traffic will go down perhaps 50 per cent. as compared with normal, and the bus service is then immediately curtailed, just as on a fine sunny day (it may be "Chestnut Sunday" at Bushey Park, or any other special event of attraction) the authorities have to be prepared to strengthen services to meet popular demand. The telephone, on such occasions, is perhaps the chief and most important assisting instrument—in fact, without it, efficient control of the "General" buses running in the streets of London to-day would be impossible.

One of the simplest developments of this kind, which claims for itself new dignity under the term "control," is that where a local goods office has obtained a new installation of telephones with provision between every section of the station, each foreman and checker's office and the agent in the office.

This illustration of an improved and more effective telephone circuit introduced locally, and claiming to establish technical control of a new order, serves very well to illustrate the main point of this chapter that what now passes as "train control" under that technical term is simply a very efficient application of telephones for the use of the trains superintendent of a railway company in the manipulation of trains.

By the addition of necessary equipment in the way of control board, diagrams, card indexes and cabinets, and train indicators as adjuncts to assist the mind in supervision of train running, a new and complex instrument has been evolved. But it is telephone development which has made this possible, and it is in the application of telephonic methods to all the complications of goods and passenger train working that the greatest development in effective control has been secured. It is to a description of the methods employed in giving application to this telephone control in train working, and to some consideration of the effect upon train working organisation resulting from these methods, that the following chapters are devoted.

CHAPTER VIII

THE ENGINE-DRIVER'S CONTROL

REFERENCE has already been made to the very different character of the control exercised by a driver to that of either a road motor chauffeur or of a railway signalman ; but in recent years much has been done to give to the driver of a locomotive mechanical assistance in the control he exerts over his machine.

One should perhaps first mention the question of brakes. Under parliamentary enactment (Regulation of Railways Act, 1889) every engine which works a passenger train must be fitted with an efficient continuous brake capable of being applied to every vehicle of the train, and self applying in the case of failure in the continuity of its action. Many goods wagons are also fitted to enable them to run on fast trains, and there is a tendency towards an increase of the number. In America all the rolling-stock, passenger and goods alike, is fitted with the continuous brake apparatus.

We have not yet in Great Britain introduced the automatic stoker on locomotives as they have done on many railways in America, by which the fireman is relieved of a great deal of his dirty work, the fire-grate being fed with coal from the tender by a mechanical appliance kept working automatically on the same lines as the automatic stoker now so commonly employed in large factories to feed the stationary boilers ; but on the Underground and other electrically operated railways the new power which has come into the service of man has made the driver's work so much simpler and cleaner that the fireman can be dispensed with altogether. The new circumstances and new aids to locomotive control make the driver's work more "intensive," if the expression may be used. The exact meaning of this will be appreciated as we proceed.

We have to admit in the first place that in the matter of mechanical details affecting the locomotive working it is in other countries that we find a much greater advance in practical operation has been made than in our own country. We shall illustrate this by reference to two of such appliances in operation in France, both of which have been adopted in the interests of safety and after many years of consideration and experiment. These are: (1) The automatic indication and recording of the speed of the locomotive, and (2) the automatic indication on the engine footplate of the position of the controlling signals.*

The historical record of how attainment of the practical application of these two inventions has been achieved, by a succession of experiments of various ingenious apparatus on the different railways in France over a period of forty or fifty years, stimulated and encouraged by periodical state notes from the Ministry of Public Works, is a record of continuous rivalry and competition as between the relative merits of varying appliances, and finally of Government intervention, through the Minister of Public Works, to emphasise the importance of some apparatus being adopted. It should be added, too, that a series of unfortunate accidents, reports of which elucidated the fact that they would probably have been obviated, had there been a system of signal indications on the engine cab in operation, has also been a considerable factor in this development.

Owing to two causes—(1) the difficulty of any decision being come to as to which standard of device is the most reliable, and (2) a feeling, believed to be genuine, on the part of many engineers and practical train operators that a mechanical repetition of signals on the locomotive would have the effect of inducing carelessness on the part of drivers in charge, and so actually introduces an element of danger—the adoption of cab signals has only recently become general in France, though the Government has, on occasion after occasion, laid down and emphasised its necessity. The position appears to be that each company is expected to do the best it can in the united judgment of its own experts. As far back as 1899 the French Government entertained the idea of the adoption of some arrangement for the automatic repetition of signals at danger on the footplates of locomotives, and urged the importance of the matter on the individual railway systems by circular note of September 18, 1899, in spite of the objection, which the Minister specifically referred to, that these appliances were held by some to dull the attention of the driver, and to become, in case of failure, a source of danger. The fact that the Minister, in the same note, pointed out that this source of danger practically disappears when the engine is at the same time fitted with an efficient recording appliance shows how intimately the automatic arrangements act and react on each other. The Minister of Public Works at this time expressed his view that the *engineering* problem involved had already been solved in a satisfactory manner.

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* In the following description of the control appliances on the locomotives in France I am indebted to the able summary contained in the Report made by M. Ferdinand Maison to the International Railway Congress held in Rome in June 1922. M. Maison has been good enough to supply me with up-to-date figures for the table given on p. 91.—*Author.*

In this matter of locomotive cab signals the Northern Railway of France may be accounted a pioneer. It is now fifty years since this company, which has always distinguished itself for the speed of its trains and for its persistent search after improved mechanical inventions in the interests of safe working, was first considering an electric contact apparatus for repeating disc signals upon the locomotive footplate, and as far back as 1880 this company brought into operation on all its lines of double track an automatic apparatus for this purpose. The apparatus announced all disc signals at danger to the driver by means of an audible whistle, the general nature of the arrangement being as follows: On the track is a contact bar, electrically energised when the disc signal is at danger, and constructed at a standard gauge so as to come into contact with a contact brush on the engine, which takes up the current and actuates a whistle in the driver's cab. There were about 1,700 of these appliances at work, and about 2,350 locomotives fitted with the necessary attachments in January 1914. To-day (i.e. September 1925) there are 4,052 signals fitted with the appliance and 2,813 locomotives. All the engines, except a few shunting engines, are fitted. The number of miles of double-track mileage on the Northern Railway is 1,392 out of a total track mileage of 2,386. This apparatus, on account of the shape of the contact bar attachment on the permanent way, is generallly known in French railway circles as " the crocodile."

In the earlier days of this installation the apparatus not only actuated an audible whistle on the engine, but it also itself, without any " by your leave " of the driver, applied the brake automatically, the driver, however, having a control handle which enabled him, if he did not think the train should be stopped, to obviate the stoppage. When, at a later date, the Westinghouse brake took the place of the vacuum, the automatic train-stopping mechanism was abolished, the company having come to the conclusion it was better to leave the initiative to the driver himself. Apart from the somewhat rare circumstance of heavy snow or a coating of ice on " the crocodile," this apparatus is said to act very reliably ; it is, of course, of vital importance to keep the batteries at the signals and the contact brushes in good order.

Some of the other systems of indicating signals on the locomotive have, as an integral part of the device, an arrangement for recording the position of each signal at danger, as well as of indicating it to the driver ; but this is not part of the Northern apparatus, though it is understood some attention is now being given by the authorities to this branch of the subject.

The French Eastern Railway, after trying a separate apparatus, decided to work an appliance similar to that referred to as being in use on the Northern, but they are aiming at eliminating certain defects such as occur through frost and snow ; and they are also aiming at recording (as well as indicating) all the disc signals, whether at danger or at line clear, and to sound a siren when the signal is at danger which shall be heard by both driver and guards ; 1,850 engines out of a total of 2,460 have, however, been fitted with a signal repeater apparatus similar to that on the Nord engines.

The P.L.M. Company has been experimenting on a long line of railway (Paris–Dijon, etc., 233 miles) with an apparatus similar to that of the Nord, and also with apparatus for recording all signals at danger. The progress this company has made in recent years is indicated by the fact that it has now 3,232 engines (out of a total of 5,343) fitted.

The State Railways themselves have had extensive trials with various apparatus, and they have recently been considerably extending their experiments, till to-day 93 per cent. of their engines are fitted.

The Midi Railway is making arrangements to equip its main artery lines with an apparatus for repeating signals on the locomotive cab, and giving an audible warning, but it intends to have some supplementary appliance for checking the vigilance of the driver. The apparatus is of the crocodile type, modified from the Northern system mainly to suit the system of electrically controlled automatic signals with which the Midi has equipped its train working.

The Orleans Company is also experimenting, but when it is pointed out that this company does not use distant signals, and that the apparatus we have so far been describing is mainly an apparatus for repeating distant or warning signals, we see that there are special difficulties to overcome in connection with the repetition of signals on the engine in the case of this railway. This serves also to illustrate the special difficulty which is met with in France in connection with any question of standardisation of signalling details or safety appliances.

Next as regards the *recording* of speed. Before referring to the appliances it should be prefaced that some of the fastest and best locomotive work in the world with passenger trains has been recorded in France, and of the French railways, as already indicated, the Northern has distinguished itself. It is no uncommon thing for 75 or 80 miles per hour to be attained by the trains between Paris and Calais and Paris and St. Quentin (*en route* to Belgium), and this with good loads of from 250 to 350 tons or more. It is recorded that a speed of 75 miles an hour was obtained on the Nord Railway as far back as 1860, and though in those early days speeds of this kind were exceptional, there has in recent years been a great development in fast running, so that 65 to 75 miles per hour is not uncommonly attained on most railways. There is a Government limitation of speed fixed for each of the French great systems, which may not be exceeded, with a maximum of 130 kilometres (82 miles per hour). The Government Technical Committee which advises the Administrations fixes the maximum from time to time in accordance with the condition of efficiency of the road-bed. Some companies are limited to 110 km. (= 69 miles), some 120 km. (75 miles), and the best are only restricted at 130 km. (82 miles). So commonly has it happened, in connection with accidents where the driver has been running at an alleged excessive speed, that evidence as to the speed was entirely conflicting, that for the sake of having the facts rightly and regularly recorded a speed indicator and recorder is adjudged essential, and has been ordered by Government decree.

The importance of having some check against obtuseness on the part of the driver to appreciate the right thing to do in the case of signals unexpectedly found at danger, or some check to indicate and record his promptness in decision and action, appear to be factors which weigh very seriously on the French supervisor's judgment. These checks are provided by a continuous record of the engine's performance by means of a tape, marked up by a pen or stylo needle, which records by graph indication on a tape the speed of movement varying in ratio to the rotation of the locomotive wheels. The apparatus which has been most continuously and extensively in use is that known as the Flaman recording apparatus. It is in use on the Nord Railway, and it is intended to indicate and record the speed so as to keep the driver continuously aware of the speed at which his engine is running and to record, during the running of the train, other necessary particulars, such as the exact speed at given (frequent) points, the distance of each such point from the commencement of the run, the length of each stop, slipping of wheels, etc. Such tape, it will be seen, provides a very useful record for subsequent reference or for report at any time to the chief mechanical engineer, and it also serves to indicate the attention which the driver has given to any warning signal; for in the Flaman design of apparatus there is marked on the recording strip, not only the indications given by the repeating apparatus, but also a record of the attention given by the driver to signals indicated against him.

The question of the adoption of some speed recording mechanism on the engine was raised by the French Government first in 1885, and has had consideration almost continuously since that date. Various appliances had been experimented with by different railway companies when in 1895 the Minister of Public Works again took the matter up, as the attention of the Technical Administration Committee had been drawn to the matter in connection with premiums offered to the drivers for satisfactory train running and for economical fuel consumption. It was thought that these premiums offered an incentive to too fast running in making up time lost; but the Technical Committee came to the conclusion that the fuel premiums ought to be continued, and that any real objection would be removed if the use of speed recorders became general.

In May, 1897, the Minister again urged on the companies the desirability of installing the apparatus on their locomotives, and as very little progress was made up to 1901, in October of that year the Ministry sent out a reminding note, and at a later date issued what was practically an order that the appliances should be installed by the end of 1908. Following upon this ministerial decree the Eastern, Western, Northern and State Railways decided to adopt the Flaman apparatus. The date had afterwards to be extended to December 31, 1910; but by the end of 1911 practically all the passenger locomotives running on the French railway systems were fitted with appliances for indicating and recording their running speeds, as well as a number of goods engines. The Government agreed that engines used for shunting purposes only need not be so fitted, but following the passenger engines the same installations were carried out in the remainder of the goods engines.

The war interrupted the complete carrying out of the order from the Ministry to have all engines (except shunting) fitted by the end of 1916, but the work was renewed in 1919, and from the table set out on page 91 it will be seen that the installation of speed recorders of approved type on French locomotives has become part of the regular equipment.

As regards the Alsace-Loraine railway system now under Government control from Paris, following an accident on the system at Creutzwald in December 1920, the administration submitted to Government a scheme for installing the Flaman speed recording apparatus upon its engines by stages in four years, and this scheme is to be completed by December 1925.

SPEED RECORDING APPLIANCES AND CAB SIGNALLING ON FRENCH LOCOMOTIVES.

Railway System.	Locomotives fitted with Speed Indicating and Recording Apparatus.							Total Number of Engines fitted with Apparatus for Signal Repeaters on the Engine, September 1, 1925.	Number of Signals provided with "Crocodile" Apparatus for Actuating the Locomotive Cab Signals, September 1, 1925.
	On January 1, 1914.		On September 1, 1925.						
	Passenger.	Goods.	Total Number of Locomotives.	Number of Passenger Engines.	Number of Goods Engines.	Total Fitted.	Percentage of Engines Fitted.		
Nord	1,338	373	3,007	780	1,727	2,507	83·37	2,813	4,052
Eastern	1,079	440	2,460	1,196	1,101	2,297	93·40	1,850	1,578
P.L.M.	3,565	1,582	5,343	3,714	811	4,525	84·70	3,232	2,757
State	2,837	1,991	4,110	2,319	1,517	3,836	93·00	2,494	2,838
Midi	1,058	795	1,340	842	426	1,268	94·60	719	1,048
Paris-Orleans	2,053	1,517	2,296*	—	—	2,159	94·03	847	1,022
Alsace-Loraine	—	—	1,637	401	492	893	54·00	—	—
Luxemburg	—	—	131	14	—	—	—	—	—
			1,768	415	—	—	—	—	—
			20,324	—	—	17,485	86·00	11,955	13,295

* The Paris-Orleans Company works its engines interchangeably for goods and passenger traffic, with slight exception.

We may well conclude this reference to the installation of speed indicators upon French locomotives with the views of M. Ferdinand Maison as to the advantages of an apparatus of this kind. M. Maison is Inspector-General of Mines in France, and Manager of the Control of the Technical Working of the French Railways, and he was selected to make the report upon this subject of appliances on the cabs of locomotives for recording and indicating signals, and for indicating and recording speed, for discussion at the International Congress of Railways at Rome in 1922. He writes :

> "It is the opinion of all the railway companies that the instrument should indicate and record at the same time.
>
> "The indication of the speed serves to inform the driver as to the speed of his train in order to allow him to follow his time-table more easily by keeping to the speeds laid down, and to avoid exceeding the maximum speeds which are provided in case of delay.
>
> "Speed recording is necessary to enable the obtaining of the details of the run subsequently within the limits of error of the apparatus, and *thence* to determine all the conditions of the run, to ascertain whether a regular speed was kept, that the maximum speeds were not exceeded, to check the time lost on the trip, the length of the stops and of shunting operations, and to apportion the blame for accident or delay.
>
> "The advantages of speed indicating and recording appliances from the point of view of safety of railways are disputed by no railway system, but are confirmed by all of them."

Germany has made provision for careful locomotive driving upon quite other lines, namely, by the selection of her drivers on really scientific lines, by the introduction of a "psychotechnic" method. It is interesting to note this difference between two countries. Both are acting on advanced scientific lines, France by the adoption of a mechanical record of the locomotive performances after giving the drivers the best available means of knowing what the engines are doing and appreciating the signal indications, Germany by a psychological test of the driver in advance, and thus by the employment of only such men as are psychologically fitted to undergo the strain which must from time to time fall upon a driver.

The German test practically reproduces the actual physical circumstances of signals which a driver has to encounter in his daily work for test purposes when a candidate is examined. The man is put through a practical test by having to manipulate his locomotive brake and control handle in the face of a large number of signal indications to which he is subjected one by one.

The three main points to which the test is directed are :

1. How quick is the " mental uptake " in the candidate ? Can he quickly grasp or visualise an obstruction ? e.g. a motor-car suddenly coming into view at an open level crossing.
2. Capacity for deciding rightly upon given circumstances.
3. How long does it take him after having decided what is the right thing to do, to do it ? e.g. put on brakes, slow down, or put on more power.

The first and third of these test points can be measured in fractions of seconds ; and an automatic electric indicator determines and records what is precisely the reaction of the man to the tests adopted. This automatic electric tape record is of great value, as it eliminates the possibility of any man raising a charge of unfair treatment of himself or of favouritism of others by the examining officials.

When a locomotive department official makes the selection of drivers, or even has the responsibility of conducting the qualifying examination, experience shows that charges of favouritism very frequently arise. The automatic device (whose record any candidate can himself see) eliminates this difficulty entirely.

The " automatic stop " arrangement by which a train which may improperly overrun its signal is promptly brought to a stand is, as explained subsequently in Chapter XV, regularly in operation on all the lines of the London Electric Railways, but it has not been adopted in England to any extent outside of the Metropolitan area.

In America, however, it is being widely adopted. Acting upon new powers conferred upon it under the 1921 Act of Congress, the Interstate Commerce Commission promptly issued a decree requiring all the large companies in the States to adopt some system of automatic stop upon large sections of their main lines in the interests of public safety not later than 1926, and these installations are now rapidly approaching completion.

Various experiments in cab signalling have been made in Great Britain in different parts of the country, but as with us this question is only in the experimental stage, it has been necessary in speaking of "control" developments on the engine to illustrate from the records of other countries what is being done in practice, especially in this matter of assisting drivers in their observance of the controlling signals and in the regulation of their running speed.

CHAPTER IX

THE GROWTH AND DEVELOPMENT OF THE NEW TELEPHONE CONTROL

It is difficult to say to whom the credit of initiation of the new system of centralised train control in Great Britain is due. The Midland Company claim to have been pioneers in the matter when they introduced their limited system of control of mineral train working at Masboro' in 1907, and they were undoubtedly the first company to extend the system to a large area of main line control.

At the same time that the Midland Company were turning their attention to this question in connection with their Masboro' and South Yorkshire coal traffic, the old "North Eastern" were very busy installing a control office at Newport sidings (Middlesbrough), to bring under better telephonic control the heavy traffic going into and out of the Middlesbrough district. Let us begin our description with the latter first.

A control station was established at Newport sidings (Middlesbrough), with a complete control board and other necessary appurtenances for the purpose of regulating and controlling the flow of mineral and goods traffic in the complex ironworks area at Middlesbrough. The control area extended from Stockton-on-Tees (Bowesfield Junction) through Middlesbrough and Saltburn to Skinningrove furnaces, a total length of about 50 miles, most of the section being equipped with up and down independent goods tracks in addition to the main passenger lines, and the whole area being intersected with private sidings, mainly for iron smelting furnaces, engineering works, and ironstone mines. A map of the controlled area in the Middlesbrough district is given at page 111, Fig. 11.

Although the installation of this control apparatus actually took place as from November, 1910, it was years before the full use of it was applied or even understood. For a long time the control board was simply used for recording the situation of trains within the area, and became a substitute for the rough pencil record books which had hitherto existed, and which recorded in parallel columns the times of trains passing each signal-box, much after the style of an abbreviated block signal record book. Some years after its establishment the controller in charge, on being questioned as to the use he made of the board, described it as a most useful *aide-mémoire*, and this is a good description of the instrument in its initial stages. There is, however, all the difference in the world between the use of a control board simply as an *aide-mémoire* and as an operating instrument on which the game of manipulating trains may be played as on a chess board, pieces are moved by a skilled player, and it was some years before such a degree of confidence and ability was attained as to justify a controller assuming, or being allowed, responsibility to " play the game."

However, whether the board was used merely as an *aide-mémoire* or as an operating instrument, the apparatus as a whole provided a very efficient method of constant communication between the train master and signalmen, and was very useful for consulting. The avoidance of calling out unnecessary engines and of detentions at various points within the control area was constantly being effected as the result of consultations and of improved supervision. By degrees a complete recognition of the superior position of the control office for purposes of advice and guidance was brought about. It will be readily understood that real success in the installation of a new overhead control system must depend almost entirely upon the efficiency of the officer in chief charge—controller, or train master, or whatever title he may be given. This point (the recognition of the train controller's position as one of authority) may be considered as a key point in train control development. A full description of train and traffic control at Newport being set out in Chapter X, there is no need to go into further detail here.

The system of control which the Midland were installing and experimenting with at Derby, following upon the more limited experiment at Masboro', took within its purview the whole of the Midland lines between London and Carlisle. Mr. Cecil Paget was at the time General Superintendent of the Midland Railway, and it was to his efforts that the extension of the system first installed at Masboro' was mainly due. As soon as the Masboro' working promised to succeed, Mr. Paget arranged to extend the principle to the whole of the Midland collieries, and a well-equipped office was established at Derby. The office at Derby was in the first instance installed with a view to some better regulation of the non-booked coal trains from the collieries, especially in connection with coal that was going for shipment to the ports, for it was realised that a great amount of congestion was taking place. Collieries are always anxious, even impatient, to get the coal despatched when they have orders for it to be shipped, and it is (or was) consequently sent away from the collieries before the ship was ready to receive it, often even before the ship was in dock. This state of affairs evidently needed co-ordination and control under the supervision of a competent officer, and by some means which would put him in possession of information, not only as to requirements at both ends of the journey, but also as to the working conditions of the railway line concerned. This phase of traffic control, and what is involved, is treated at some length in Chapter X in connection with Hull, as well as in Chapter XII dealing with the L.M. & S. control.

The first instructions were issued by the Midland in pamphlet form on December 14, 1908. They were to the effect that commencing on January 4, 1909, the movement of goods and mineral trains between Cudworth and Toton would be "under the control of the district controllers, situated at Cudworth, Masboro', Staveley, Westhouses, and Toton, from whom signalmen are liable to have orders affecting their own work, or instructions to transmit to other members of the staff respecting theirs." In the *Railway Gazette* of April 25, 1919, an article describing this train control system on the Midland commenced with the following words :

> "The Midland Company was certainly the first of our great railways to make a bold plunge and operate the whole of its system through district controllers, working under a central control at Derby."

As to the exact priority in time of the commencement of these various control systems, it is not easy to pronounce, and the matter of exact dates is not one of importance. The Underground Railway Company in London were also installing their method of train working control referred to in Chapter XV. About the same time that the Midland were experimenting at Derby, the Lancashire & Yorkshire commenced and developed their system of control at Victoria Station, Manchester, and their installation steadily developed for a few years, until it became a most efficient apparatus of train control covering the whole of the Lancashire & Yorkshire's system of main lines. When completed, by about the year 1917, the apparatus was centralised in one large circular office at Victoria Station, Manchester, around the circular walls of which were seventeen control boards, each representing one section of the Lancashire & Yorkshire system, and on the upper part of the wall the diagrams of the seventeen boards were combined into one diagram of the whole system. There was a " controller " in charge of each of the seventeen sectional boards, who was in telephonic communication with signalmen at the local control points in his own area, and there was one chief controller whose function it was to keep watch over the entire system, and give advice to his assistants in case of emergency, or in any case when they wanted assistance.

Prior to this complete establishment at Victoria Station, however, separate controls had been established in 1912 and 1913 at Liverpool and Manchester, respectively; these, with others, were combined under one central installation at Manchester in August 1915. An important further installation for the Miles Platting district was added in 1916, and the complete scheme dealing with the whole system was finally in operation before the end of 1917.

It should be added that the Lancashire & Yorkshire apparatus only dealt with the freight trains, but when completed it covered a larger district than had previously been centralised for train control purposes, and it was very complete in all of its details. The movement of trains was recorded on each of the seventeen sectional boards by means of pegs placed by the assistant controllers as they received information from the signal-cabins or control points, and the whole of the information as to train positions recorded on the sectional boards was combined on one general system board displayed on the upper part of the control room wall. This repeating of the sectional information on the whole-line board was accomplished by automatic device, the insertion of the pegs (representing trains) in the holes in the sectional boards operating electric lights of different colours on the combined control board. This control apparatus at Manchester (Victoria) Lancashire & Yorkshire, is fully described in Chapter XI.

The Lancashire & Yorkshire Railway became amalgamated with the London & North Western system as from January 1, 1922, and when the train control arrangements in the Lancashire & Yorkshire area came under the supervision of Euston they were very complete in character.

But further developments were taking place both on the London & North Western Railway and on the Midland. The control arrangements at Derby rapidly extended, and embraced carriage and wagon control as well as train control; and then a great measure of devolution was given effect to, a local or district control being established in each of the twenty-five districts into which the Midland system was divided, the main line train running and principal trains only being dealt with at the Derby office.

It should be noted that the Derby control office was a development following initially upon a much more limited experiment by the Midland Railway officers in South Yorkshire.

The main object which led to the establishment of the Midland control was the reduction of trainmen's hours to more reasonable limits. Very heavy congestion of traffic from the Yorkshire and Nottinghamshire collieries, especially in connection with traffic going into the Hull district, had been taking place, resulting in bad train delays and detention to enginemen and guards. With a view to more systematic relief of trainmen, an office was opened at Masboro' well furnished with telephones, and this led to a considerable measure of effective control over the mineral train working, and to a much better system of trainmen's relief.

This new mechanism of so great importance in aid of direct supervision having been installed, it was very soon found that the improved method of control was capable of almost indefinite expansion. A full account of its attainments up to date and present functions are set out in Chapter XII. Here we would only emphasise the three important stages of development, the inclusion of passenger trains in the central scheme, the devolution of the goods train control to the district offices, whilst only the important main line trains were retained in the central office, and the extension of central control to include rolling stock allocation and distribution as an integral part of the superintendent's control system. The working and make up of all passenger trains between St. Pancras and Carlisle has been retained in the Derby office, and with very beneficial results.

The London and North Western Railway were developing and improving their " control ' arrangements side by side with the Midland, and several years before the great amalgamation of 1923, they had the whole of their main line " under control," but different sections of the line were experimenting with different applications of the central control idea. Perhaps the chief difference in the equipment of different control offices was found in the character of the control board, some sections preferring what is known as a " time board," whilst others pinned their faith to a geographical board on the lines of the Manchester one. Some, indeed, regarded the board as of very little importance. The difference between the two descriptions of board is described in Chapters XI and XII. It is so great a difference as almost to constitute a difference of principle in the method employed.

The general organisation of the London & North Western control system was much on the same lines as the Midland, the control being directed from sectional offices, of which there were about thirteen, the principal ones on the main line in geographical order from London being Willesden, Bletchley, Nuneaton, Crewe, Warrington, and Carnforth.

The tests which had been made of the various modifications of the system in these thirteen offices undoubtedly afforded the successors of the London & North Western Company valuable experience on which to base their final or further choice of a good and efficient system, and the fact that the very excellent methods which had been found of so great value in traffic working, obtaining at Victoria, Manchester, on the old Lancashire & Yorkshire, and in the Derby office and its connections of the old Midland, now all come under the one management along with the old London & North Western as the united London, Midland & Scottish Company, creates a very interesting situation, pregnant with great possibilities.

Mr. J. H. Follows, the present Chief General Superintendent under the united company, is an enthusiast for the development of the system upon the best possible lines (he was successor to Mr.—now Sir—Cecil Paget on the old Midland), and it is to Mr.—now Sir—Arthur Watson, the General Manager of the London & North Western after it became amalgamated with the Lancashire & Yorkshire system in 1922, as much as to anybody that these train control methods have been advanced, firstly on the Lancashire & Yorkshire system, and afterwards on the old London & North Western Railway.

The North Eastern Railway have made considerable extensions of the control system upon their area since the Middlesbrough district control was installed. In September 1917 the important concentration lines round about Newcastle-upon-Tyne, including the two bridges (the old High Level and the King Edward), were brought under a control system similar to that in the Middlesbrough district; and in the autumn of 1922 an important installation was opened at York controlling the main lines of the East Coast route running from Doncaster to Newcastle-upon-Tyne—112 miles. North of Newcastle the traffic density on the main line is of a much lighter character.

In 1923, also, a control office for the control of goods and mineral traffic working to and from Hull was opened at Hull under the charge of the district superintendent there. The functions of this office are described in Chapter X. The York installation has some very novel and interesting features; these also are described in Chapter X.

Doubtless it will be of advantage to the student or general reader to have followed the foregoing short historical review before going on to the consideration of the facts of to-day in relation to specific installations, for the survey of recent developments necessarily carries along with it the suggestion of further evolutionary development as the improvements stage by stage become appreciated, and as the needs of specific circumstances and localities come to be understood.

The writer does not wish it to be inferred from anything he has said that he is advocating any one system as being of universal or general superiority. Different methods are required for differing circumstances, which depend *inter alia* upon whether the control is for irregular and unbooked goods or mineral trains, local working, long distance passenger trains, or urban or inter-urban passenger working. Just as in designing a passenger station, or the layout of a wagon marshalling yard, or a dockyard area, it is essential to know and analyse your traffic so as to adapt the accommodation to the circumstances of traffic movement, so it is with a system of telephone control for trains. There are four principal categories of varying descriptions of train working into which a central train telephone control may be divided, each of which needs separate and special consideration.

1. Irregular or unbooked goods trains in ironworks or colliery districts where there is an aggregation of heavy traffic varying day by day.
2. Main line long distance train working, (*a*) passenger, (*b*) goods and mineral.
3. Branch lines with attenuated traffic.
4. Urban or suburban passenger traffic in dense areas where trains keep almost regularly to their booked times and it is essential that they should continue to do so.

These four headings have relation to control on the railway lines only, and leave out of account the similar method of control of cartage vans and rully teams in a city like London (already referred to) or other urban area. According to the circumstances of the traffic must be the description of the "control" apparatus provided. Even a railway man accustomed to the control of passenger trains in a busy urban area where the trains run regularly to time, and practically under normal circumstances control themselves, would have very little idea of the meaning of a control office and board applied to some heavy density area, where the running of every goods and passenger train has to be specially watched and regulated.

We may venture at this stage to enumerate under certain heads the principal functions assumed to-day at train control offices—functions which now take rank as part of the normal duties of the controller in charge.

1. *The Provision of a Visual Indication*, by means of a control board, of the train working in the area selected for control. This is a feature common to all control offices.

2. *The Keeping within Reasonable Limits of the Trainmen's Hours.*—This is a function which brought several of the control systems, e.g. the Lancashire & Yorkshire and the Midland into being: it is now a function of the London & North Eastern Railway control offices, of the London, Midland & Scottish Railway, and indeed of all the control offices.

3. *The Supervision of Freight Trains within the Control Area*, with a view to getting them over the rails with less detention *en route*, by more careful manipulation of train margin times. This is a function which is common to all control offices so far established.

4. *Traffic Control and Regulation.*—Where a system has developed over so wide an area as in the case of the present London, Midland & Scottish system of control, the two functions of train working and traffic regulation become so intermingled and interdependent that both are given effect to; the function of the controller being daily to ascertain the exact position and circumstances of traffic ready for conveyance or in course of conveyance, and base all the train arrangements upon the information so ascertained.

In other offices controlling more limited areas such as the York, the Hull, or the Middlesbrough offices of the London & North Eastern Railway, a similar combination of duties may be seen at work, although given effect to in different manner. At Middlesbrough the train working, except as regards daily "extras" or special trains required, is arranged from the superintendent's trains office upon the information as to traffic which the control office supplies. Similar is the arrangement at Hull and at York; but in all three offices the two sets of controller exist (traffic and trains) side by side, the degree of authority vested in the train controller varying.

5. *As a General Train Controller and Supervisor.*—When the chief of a control office carries out duties which justifies

this description of his duties as a train controller, he becomes practically a high grade chief of the district superintendent's trains' office. This is the position of the controller at York, Middlesbrough, and Hull, but of course only in so far as the districts under control are concerned.

With the London, Midland & Scottish Railway, the centralised functions are so extensive, that whilst there is a controller whose authority gives him the position of chief controller, he has several assistants, each of whom has a very large amount of authority for sectional or departmental work —one for all passenger excursion traffic, one for shipment mineral traffic, one for wagon distribution, one for carriage control, and so on.

6. *As a Rolling Stock Control Office.*—The London, Midland & Scottish Company is the only company which combines rolling stock control with its train control organisation. In the case of the London & North Eastern Railway an entirely separate carriage and wagon control exists, very efficient in its nature. But much of the local wagon distribution and allocation and the taking of daily censuses is carried out by the control office acting under the directions of the general rolling stock superintendent.

7. *As Controller of Locomotive Power.*—To a very large extent at the present time the train controller has become controller over the locomotive power in his district. But he is rather a manipulator of engines than a controller. Under the London, Midland & Scottish arrangements, where all the working stock of locomotives are under the control of the general superintendent, the engine supply in each district is under the engine-shed foreman, who is attached to and in charge of each engine shed; but these two officers, the shed foreman, and the section or district trains controller, are in such close touch with each other that they work practically like joint officers over one job, the shed foreman concerning himself with keeping the engines in good working order and repairing their defects, whilst the controller has complete authority over the daily manipulation of engines when they are "in traffic."

In the Manchester system, the locomotives are under the separate control of a mechanical engineer, but this officer always keeps a responsible assistant in the control office to consult the controller, and to see that all the latter's reasonable requirements are complied with.

The arrangements on the London & North Eastern Railway are very much the same : at all the control offices special trains as required outside the normal working are arranged under the authority of the controller; and the locomotive running superintendent, although an independent officer, reporting directly to the area general manager, is, of course, expected to meet controllers' requirements as far as is possible. Although, therefore, the train controller is not a controller of locomotive power, he supervises the distribution of available engines. The real control of locomotive power is a joint responsibility under direction of the superintendent.

At certain offices where a fully established control system for goods and mineral traffic exists, a conference takes place early every morning between the traffic controller and the locomotive foreman as to the precise number of locomotives required for the day, as far as can then be seen, and arrangements are made accordingly.

8. *Control of Passenger Trains.*—On the London, Midland & Scottish Railway system there is—as will subsequently be described—a very efficient passenger train control at Derby which embraces supervision of the running of all principal main line trains between St. Pancras and Carlisle. Passenger trains are not in any way brought into the control system of the *sectional* offices. On the London & North Eastern Railway at York similar supervision in the control office takes place over the East Coast trains for the section of line from Doncaster to Newcastle. In both these cases—Derby and York—the running of the trains so far as regards work at stations, load in vehicles, and lateness or detentions in running, are kept track of on recording sheets : the records are made concurrently at the time of running.

At the Manchester office, although passenger trains are not brought into the general system of control working, special arrangements are made for a few of the principal passenger trains to be recorded in the office, as the control machinery provides so convenient and efficient a means of collecting the necessary information in regard to the train running. The sheet records as completed are subsequently inspected and scrutinised by the superintendent's trains office chief.

9. *Control of Goods and Mineral Vans.*—This is a function which very conveniently and suitably falls upon a control office, and fits in with their duties. At an office like the Derby one, for instance, a weekly census of all vans and their whereabouts is obtained, and allocation made with a view to seeing that the most economical use is made of every van.

Under the above nine heads we have enumerated the main functions which are being assumed by the control office under the new system. The new method of supervision and control will no doubt grow, and grow fast enough as its advantages become better understood: but it is of importance that too much centralisation be not attempted all at once. If too many varied functions are thrown all at once on to a central control office before the controlling personnel have had time to become educated to their duties, the result may be disastrous. New functions should be added one by one as the new personnel is educated up to a capacity to undertake them. The dangers of too rapid centralisation are referred to in Chapter XIX ("Responsibility").

CHAPTER X

EXPERIMENTS ON THE LONDON AND NORTH EASTERN RAILWAY

We may now describe experiments which are taking place on the London and North Eastern Railway, dealing by way of illustration with the important installations which have been carried out on the old North Eastern area of the amalgamated company. These installations are four in number: there are other local area "controls" at Leeds, Manchester and Doncaster.

It has already been pointed out that the first goods train control experiment was installed in the Middlesbrough district in November 1910, and was the forerunner of the further developments which are described in this chapter. Then in 1920 the busy Newcastle-on-Tyne section was brought under "control," this experiment being in the first instance for goods trains only, and being in character very like the one adopted in the Middlesbrough district. Thirdly, in the summer of 1922 the extensive installation at York was brought into use as a measure of control over all the main line trains—goods *and* passenger—running between Doncaster and Newcastle-on-Tyne, about 112 miles. About the same time was installed a fourth section in the Hull area to bring under "control" the important goods and mineral traffic arriving at and departing from Hull. It is proposed now to describe the distinctive features of each of these four experiments in turn.

We would, however, first point out what are the distinctive features which the North Eastern authorities claim for the particular methods of control they are employing. First of all it is pointed out that a traffic control and a trains control office fulfil different functions, and that whilst the Newcastle and York offices are joint trains and traffic control centres, the Middlesbrough and the Hull installations are primarily traffic control offices although a certain amount of train control work is done in each.

Whilst the difference of train and traffic control may be clear enough in principle, in practice it is almost impossible to separate the two functions. So far we have been speaking of control offices as having been established for the purpose of supervision and control of train running. The theory of a *traffic* control office postulates the main duty as being the obtaining and concentrating of information as to traffic to be moved, and then making arrangements, either by special or by ordinary train services for the movement of the traffic to the required destinations in as economical a manner as possible. If the controller proceeds to make his own arrangements with the control staff for hauling the traffic direct it becomes *ipso facto* a train control office. If the control office, having obtained information as to traffic requiring conveyance, merely passes on such information to the separate superintendent's trains' office, the control office (so called) hardly seems to justify its name. It would rather be of the nature of a traffic clearing-house or information bureau. But, as a matter of fact, all traffic control offices combine the function of train operating in some degree with that of a traffic information bureau.

Every trains office must have regard to traffic, for it is the quantity of traffic which must determine the extent of train service day by day. Indeed, the whole idea of *control* in connection with train service involves the two ideas of trains and traffic, and the essence of the principle of control is primarily the adapting of the former to the requirements of the latter. As we describe the North Eastern control offices we shall be able to take note how—at least in regard to the Middlesbrough and York offices—the distinction between trains and traffic control has been carried out in the office organisation.

MIDDLESBROUGH DISTRICT CONTROL

Beginning, then, with the Middlesbrough office, it was the first installation of its kind on the North Eastern Railway. The office is situated really at Newport, the name given to the extensive system of sidings to the west of Middlesbrough itself. These sidings are at a strategic point commanding all the traffic entering the Middlesbrough area. Stockton lies about 2 miles to the west, and from Stockton through Newport, Middlesbrough, on to Redcar and Saltburn and for several miles beyond the railway traverses a succession of busy ironworks, blast furnaces and ironstone mines, all of them equipped with their own private sidings and forming a very busy industrial area.

The total length of line is about 50 miles, and for a considerable distance there are separate lines for the goods and mineral traffic in addition to the regular passenger lines.

The control office itself is, in outward appearance, very much like a large signal cabin, the upper floor being surrounded by glass windows, so that the controllers working within have before them the railway yard in full prospect. In the centre of the main control office is a table on which is the control board—a long board equipped with raised miniature rails which are really a replica of the actual running rails representing the whole of the area under control, and the board is geographically marked with the names of stations, signal-cabins and local control points, engine sheds, and, of course, all the junctions and running relief lines. On this control table or board the moving trains are pegged.

The functions fulfilled at the Newport sidings just outside the control office are as follows :

1. All coal and other freight traffic coming into the area destined for the blast furnaces, dock sidings or stations, is received in these sidings.
2. All empty wagons returning to the ironstone mines and to the dock at Middlesbrough are also received here.
3. The foregoing sets of wagons are despatched to the sidings of their several destinations eastwards.
4. The converse operation also takes place. The loaded ironstone wagons coming from the mines enter the sidings and are despatched thence to their varying destinations westward; and the same operation takes place with all the traffic going away from the Middlesbrough dock or from the Middlesbrough area generally—southward, westward, or northward.

The chief controller, who is the head officer responsible at the control office, is named the train master, and it is his business, with his assistants, to make up the trains in the Newport sidings with as good loads as he can arrange. These loads are despatched to York, Newcastle, or Leeds, and through these points to all parts of Great Britain. It is in giving effect to this function that the control board and the information which has become concentrated in the control office are brought into play. The primary instruction is that no train or locomotive must enter the area of control without consent being given by the controller, and as soon as a train enters the area, or an engine comes out of any engine shed within the area on to the main line, it is immediately, on a report received by " control," pegged on to the board with an appropriate tally or ticket, so that a relief officer or a visitor at any time entering the office and looking at the control board can see by the arrangement of tickets pegged thereon precisely how many trains are moving about in the area and just where each one is located.

We may now define the duties of the controller as set out in the official instructions. They are " to regulate the arrival and departure of trains in the controlled area and so avoid congestion ; to reduce light running ; to regulate trainmen's hours, keeping them as near normal as possible ; to facilitate generally the working of traffic by having all the information as to the position of trains and traffic to be moved concentrated at one place, whereby foremen and others will be enabled to get reliable information promptly."

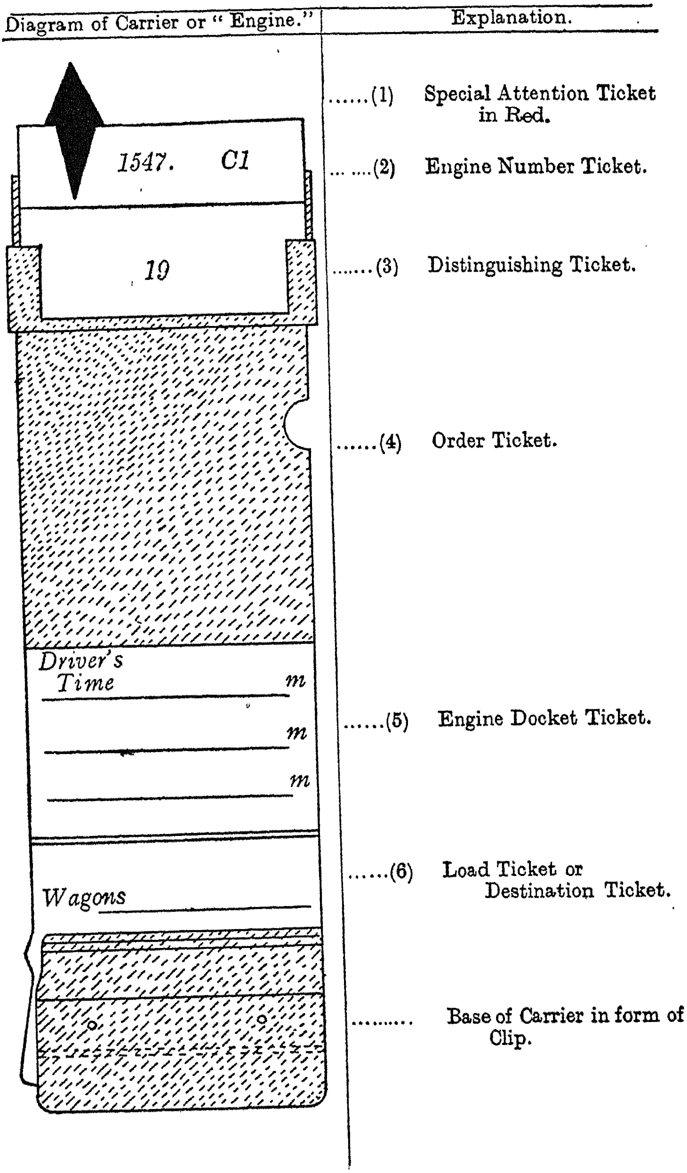
In detail the controller is charged also with ordering additional engine power over and above that already arranged for booked trains and authorised shunting engines ; to cancel any engine no longer required for traffic ; to make arrangements with receivers and senders of goods in regard to the running of any special trains through a controlled area ; to move traffic from point to point as expeditiously as possible at the time required by the forwarding and receiving points ; to obtain the maximum amount of work out of the locomotive power supplied by (*a*) using the fewest locomotives possible, (*b*) incurring the minimum of light mileage, (*c*) securing the maximum workable loads, (*d*) preventing congestion and delay by regulating converging streams of traffic; to regulate the men's hours, getting as many men as possible a full normal day's work without incurring undue overtime; and to regulate freight traffic in case of accident within the controlled area.

A diagram of the railway area controlled from Newport is given in Fig. 11.

As regards the organisation of the office: A section of the staff—two assistants—is devoted to the organisation of the traffic inwards and outwards in the Newport yard, and the making up of outward trains, or the distribution of incoming train loads. At frequent intervals during the day a census of traffic standing at the various points in the controlled area is obtained, and also of the empty wagons which are accumulating at the sidings and stations with a view to getting them moved away to points where they are required. Under these two assistants is concentrated full information as to traffic and wagons in the area which require to be moved. This information forms the basis enabling the superintendent to make up his trains. In the same way information as to *empty* wagons is telephoned to the wagon controller, who has a separate office, and whose function it is to see that economical distribution of empty wagons is made in the immediate district. These two officials, or assistant controllers, have full command over the traffic; they are known as "controllers-stocks": they are traffic controllers.

The actual train running is normally determined in the superintendent's office, but the making up of trains and the distributing of wagons as brought in by the moving trains are functions so closely allied to the actual train working that a line of demarkation would be very hard to draw. In principle, however, it amounts to this, that the control office marshals the information as to trains and traffic, and the superintendent's trains' office then manipulates the trains in consultation with the controllers.

There are one or two special features in connection with the Newport office to which attention may be drawn. The ticket referred to which represents the train on the board is carried in a clip, which easily fixes or slides upon the rail and can be moved along as the train passes successive points. An illustration of one of these tickets is given on page 112.



......(1) Special Attention Ticket in Red.

... .(2) Engine Number Ticket.

.......(3) Distinguishing Ticket.

......(4) Order Ticket.

......(5) Engine Docket Ticket.

......(6) Load Ticket or Destination Ticket.

.... Base of Carrier in form of Clip.

FIG. 12.—SAMPLE TRAIN TICKET AND CLIP USED ON MIDDLESBROUGH CONTROL BOARD.

The ticket is divided into sectional spaces which provide for the engine number; space on which the train orders can be entered; the driver's time docket showing when the driver booked on; space for the destination and number of wagons. Thus the particulars of the ticket give a synopsis of the train and its work. A small red diamond-shaped clip is shown at the top of the ticket in the illustration, and any train which is marked with the "red cap," as it is called, requires special attention to be given to it. At the Newport office only goods trains are dealt with.

The organisation of personnel in the office is on the following lines:

Under the chief controller [who is the "train master"] are controllers, assistant controllers and telephone clerks. There are two stocks controllers, No. 1 over goods traffic, and No. 2 over mineral traffic, and there are two trains controllers, one for the section west of the office, and the other for the section east of the office. The second controller (stocks) and the second controller (trains) act as assistants. There are three shifts or turns of duty, as the office is always open excepting on Sundays. Then there are telephone clerks: one chief clerk, whose business is mainly correspondence and supervision (he is only required during the day shift), and two others who receive and transmit information by telephone for the controllers; and these two clerks work alternate shifts, but as they are not needed in the middle of the night, two shifts per day are made to suffice.

The Middlesbrough office has never attempted any control over, or recording of, passenger trains. Though it prepares the daily census of empty wagons (taking a record oftener than once a day for its own purposes), it has never superseded, or been amalgamated with, the rolling stock control of the London & North Eastern Railway Company. It is primarily a traffic-regulating office with a good *aide-mémoire* control board.

TYNESIDE FREIGHT TRAIN CONTROL

A control office very similar to that which has been described at Middlesbrough (Newport) was opened at Newcastle Central Station in September 1917, and the functions of the Newcastle office were carried out on quite similar lines to those of the Newport office.

The main function of the control office, which dealt in the first instance with goods trains only, was also in this case described, as in the Newport case, to "regulate the arrival and departure of trains in the controlled area and so avoid congestion; to reduce light running; to regulate trainmen's hours, keeping them as near normal as possible; to facilitate generally the working of traffic by having all information as to the position of trains and traffic to be moved concentrated at one place, whereby foremen and others will be enabled to obtain reliable information promptly." It was provided that no trains were to enter the controlled area, or make any movements within the area except with the controller's permission. The controller was responsible for ordering any additional power beyond that fixed normally, and it was laid down that the controller must be consulted before any engines were despatched from any of the yards or traffic points with light loads or only with vans.

The control office was also charged with making the arrangements for the relieving and booking off of trainmen within the area when this was necessary.

The controller was also instructed to ask for an explanation of any detention when he considered that undue engine time was being occupied.

When the office was opened a special appeal was made to all the staff connected with traffic working in the Tyneside controlled area, that they should co-operate to the fullest extent with the controller in conducting his work, carrying out his instructions as received and rendering him all possible assistance in the way of information or suggestions, and consulting him for guidance when necessary.

The general function of the freight train controller in the Tyneside area was so much on the same lines as that at Newport that it does not seem necessary to dwell further upon the arrangements in this particular section.

TRAFFIC CONTROL AT HULL

The control installation in operation on the London & North Eastern Railway for regulating traffic in and out of and at Hull is peculiarly interesting as an illustration of traffic control rather than train control. We have already pointed out that it is not easy to determine the distinction in principle between these two forms of control; indeed, in practice they nearly always overlap.

Traffic is undoubtedly dealt with apart from trains when it is collected or delivered in the towns: and such a control system as we have described as in operation at Somerstown (pages 80–81) is clearly a "traffic control," not having anything to do with trains. It is known as cartage control—one form of traffic control. So a telephone control within a goods station which assists to supervise the goods as they are being loaded in the station is a control of traffic rather than trains, as it is only concerned with loading up traffic—not with movement of trains. But the normal condition of railway traffic in process of conveyance is as part of the contents of a train, and in that sense control of train working must include the control of traffic movement.

To understand, therefore, the distinction recognised by the railway authorities in connection with this Hull control office (namely that its function is the regulation of traffic rather than control of trains), it is essential to pay careful attention to the local facts and conditions.

Roughly speaking, 3,000 wagons of coal are received at Hull every day, mostly for shipment, and 3,000 wagons of goods, mostly imported, are forwarded inland. [The goods forwardings from Hull represent nearly 10 per cent. of the total wagons despatched every day on the whole of the London & North Eastern Railway system.] But it is the circumstances of the coal working that make the regulation of the traffic so important a factor. Let us consider for a moment how entirely different the conveyance of coal for ships, i.e. for export, is from all ordinary traffic. The latter when loaded is ready at once for destination, and may be promptly conveyed forward, knowing that it can be received at destination by consignee. Not so with shipment coal. At a port like Hull ships are coming and going in constant succession, and as each boat comes in requiring coal, it hopes and expects to find its coal cargo (or bunker) waiting for it. In order that it may be so ready the shipmaster—or rather his agents in port—have ordered coal from the colliery a week or a fortnight, or a month or more in advance. It is never known precisely when a vessel at a port like Hull will arrive and depart, especially as regards coal cargo boats. Now if the colliery at once fills the order and despatches coal, Hull sidings will very soon be choked up with coal sent from collieries for ships which are not yet in port; this traffic is then only worked forward to Hull when it is known that the ship requiring the coal will be ready to receive the cargo almost immediately after it arrives. The position at any given moment is that scores of collieries have orders for coal to be supplied to ships which are in the docks at Hull or are expected within the next few weeks. And it is the business of any railway company to regulate the traffic forward only as it can be dealt with conveniently at the port, and so endeavour to arrange things that ships requiring coal are detained in dock with as little delay as possible.

The function of the traffic controller, then, is to regulate this coal traffic in the way indicated, and though he knows by his control apparatus just where all the coal in process of movement—or, indeed, all coal which is on order—is at any moment, he has no authority over train movement. He can talk to signalmen *en route*, and inquire as to traffic, *but he has no authority to instruct the signalmen on train working matters.*

We may briefly then describe the arrangements of the Hull control office.

In the first instance it is located in the centre of the town and right away from any view of railway or trains, so that the great advantage claimed for the Middlesbrough office that it is in a commanding position in regard to view of traffic and trains coming in or leaving the principal control yard cannot be regarded as in any sense a primary need. It is claimed that as the control board and the telephone installation give the visualisation that is necessary, a direct view of train working is of no vital importance; what is much more urgent is that the control office should be in juxtaposition to the superintendent's office, and here, in Charlotte Street, it is practically part of that office. The superintendent's trains office staff who supervise the traffic control, and the wagon control office who work in closest association with it, are all located here under one roof; and this in itself makes for efficiency and prompt action.

On entering the office we see to the right hand the control board with three assistant controllers in attendance (these being spoken of as controllers (movements), and on the other (left) side are two assistants known as controllers (stocks), each having a set of telephone switches and a telephone; whilst on the end wall at the far side of the room is a blackboard on which are entered in chalk the steamships which are loading or unloading at the various docks in Hull.

It is the ships in the docks at any moment that form the key to the daily working of Hull trains and traffic, and the list of these ships is on the board and prominently displayed.

The control board is quite simple. It reaches along the wall of one side of the office and is a diagrammatic map of the section of railway under control. At the right-hand end of it are set out all the yards, sidings, and docks at Hull, occupying perhaps one-third in length of the board, and the remainder of it is taken up with the two running lines communicating with the West Riding:

1. Hull to Thorne Junction and the old Great Central, and Hull to Gascoigne Wood; * and
2. Hull to Cudworth Junction, the old Hull and Barnsley route.

Any goods or mineral train on these lines is represented by an appropriate ticket clipped on to the board, and moved along as the train proceeds and passes each successive control point. All the signal-cabins are marked on the board, as well as the control points, but the latter only are in direct communication with the control office. At certain places the local signal-cabin acts as a control point, but more commonly it is a local mineral inspector who performs this function. Passenger trains are not taken account of on the board.†

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* Gascoigne Wood is the large mineral marshalling yard which controls the train working and wagon supply to and from the Yorkshire collieries.

† This geographical control board has been abandoned since the above description was written and replaced by a time diagram board on which the actual train running is described currently in pencil by the controller, and a permanent record of each train is thus secured for the district superintendent, to whose office the sheets of graphs are sent day by day. Blue pencil is used for ordinary running and booked stops; red is used for signal delays; and green is used for the slow lines where a third and fourth pair of rails exist. The principle of the time chart is much the same as that shown in Appendix VII (Chesterfield to Trent).

All the shunting engines at Hull and all pilot working between the various Hull goods yards or docks are UNDER DIRECT CONTROL OF THE CONTROLLER, so that, within the Hull terminal area, the train working—in this case it is perhaps rather wagon working than train working—the controller is directly responsible.

The controller operates through his telephone instruments, and for this purpose there is at the Hull end of the table and board a group of telephone switches to all points in the Hull area. At the other end, half of this side of the office—controlling the train-running lines—is a similarly equipped telephone switch board communicating to each control point on the line up to Stainforth and Cudworth Junctions respectively. The stocks controller also has his separate telephone circuit to Gascoigne Wood and the various colliery connections, so that he may discuss and arrange matters at any time with the collieries, or with the Gascoigne Wood local control office.

Remembering now our main point, namely, that traffic control is the chief feature at Hull, we may consider the machinery brought into play. It is mainly a marshalling of facts and information, and using such judiciously for traffic regulation; largely this consists of the releasing of coal on hand at the collieries for conveyance to Hull.

First the coal is ordered from the collieries. This is usually done by the exporters, though occasionally the ship's agents themselves order bunkers. The order may be given a month or more in advance, but more often a week or so before the coal is wanted. A shipping order (Appendix II), giving full particulars of the coal required, is lodged with the railway company and, after being checked and registered, this is passed to the controller. The second stage is then for the control office to know when the coal will be required. The controller is therefore advised by the dock superintendent as to the date on which each ship is expected to be ready. If a vessel arrives with inward cargo, the coal is not worked forward until she is ready to receive it, but if a vessel is coming to the port light, the dock superintendent indicates the date on which she may be expected to arrive and berth. In making arrangements for the coal to be worked forward the controller endeavours to ensure that it shall be available when required, but that it is not kept on hand at Hull longer than is absolutely necessary,

With the control machinery which has just been described the control office is able to watch the traffic, having particulars of every wagon and its contents at each stage of its journey ; and on arrival at the Hull sidings it is directly " controlled " at Hull, and can be worked hour by hour by the control office as information is received from those responsible for loading up the ship, and as they indicate to the control office that they require this, that, or the other wagon or set of wagons.

So that the practical outcome is that control office keeps, so to speak, its finger and thumb on every wagon of coal traffic after the order is given, or rather after the coal is loaded into the railway wagon. This is what is meant by TRAFFIC CONTROL. The ships' agents or merchants may order coal forward for their ships, but unless the ship will be ready to receive it the railway company does not start conveyance, for the merchant cannot take delivery : he has no accommodation at Hull in which to store it. It could only stand in the railway sidings, and block them, causing congestion of traffic.

One may imagine what the position was like in days gone by before any such system of control was introduced—the colliery filling orders and despatching wagons long before the ship had even arrived in the Humber, and sidings—in times of special congestion even running lines as well—so blocked with traffic that things very often almost came to a standstill. Then a general order would have to be given from Hull, " Stop all traffic until further orders : lines and sidings congested." Under a proper system of traffic control this position cannot really happen, for the running lines are—as a first principle—kept clear for the daily and hourly requirements of moving trains.

" Traffic control," it will be gathered from the explanation now given, really postulates a certain amount of train control : the traffic controller holds up or releases coal traffic at the collieries ; he watches it as it is in course of conveyance, and he entirely controls the movement of the traffic at and around Hull, i.e. when it is in the charge of the Hull yard master and the shunting engines. He does not, however, as has been explained, give the signalmen orders as to how they shall regulate trains once *en route*. The movement of trains on the running lines until they reach Hull, or in the inverse way after they have left the Hull yard, remains under the signalmen's own control.

We may now describe the staff in the Hull control office, and then it will be helpful to comment on one or two features of the office equipment other than the telephones and control board which we have described already.

* The supervision of the control office is directly from the district superintendent's office. (This, it may be noted in passing, would not be possible unless the control office was in close proximity to the superintendent's own staff.) The chief controller is, in fact, the assistant to the superintendent who has charge of train working and wagon control and distribution. The sectional chiefs in the control office rank therefore as assistant controllers, though they are commonly spoken of as "controllers." Of these there are two in charge of traffic movements, one in charge of the running line and one of the Hull shunting locomotives, with one assistant: one in charge of traffic stocks, who has two assistants. This number represents one shift only, and there are three shifts in the 24 hours, as the office is always open. In addition, there are during the busiest parts of the day, for one shift only, two controllers who make arrangements with the collieries or merchants, one for the Hull and Barnsley Railway route via Cudworth, and one for the old N.E.R. route via Gascoigne Wood. They also between them have an assistant. In a little office adjoining are three clerks of the MINERAL COMMERCIAL DEPARTMENT, who are kept busy answering enquiries from the trading public concerned; they have access to all the control office information, which provides them at any moment with a visual synopsis of traffic movements, and they act as a sort of buffer between those engaged in traffic movement and a constant stream of impatient traders who are continuously putting forward demands or complaints, some reasonable, some very much the reverse. But it may be added here with satisfaction that the trading community generally now recognise the efficiency and

advantage of the new system, and though enquiring traders do not get all they want in the way of urgent dealing with their own particular traffic, they can at least get prompt information as to where the traffic is, and generally good reasons for any detention to which it may have been subjected. General information about traffic is very much more readily accessible than was possible in pre-control days.

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* Since this paragraph was written I understand some considerable rearrangement of staff has taken place, so that the arrangements here described do not represent to-day—1926 —*Author*.

We may epitomise now the functions of these controllers: First the controller (arrangements) fixes with each forwarding colliery the traffic and the number of wagons which may be sent forward; for this purpose one shift of two men and an assistant is sufficient—this is during the colliery management day hours. Secondly, the controller (movements) then watches the traffic worked forward to Hull, and his colleague who is in charge of the Hull pilots and shunting then takes it in hand until it is safely at destination in the ship's hold or bunker hatches. Thirdly, come the controllers (stocks), who have charge of all the traffic waiting or moving about in the Hull yards—east and west respectively—and it is their function to supply any wagon of coal as it is asked for by their colleagues, to deal with empty wagons and generally to distribute the traffic of which they are expected practically to keep a continuous census in accordance with the due destination of each wagon.

It should here be noted that not only is every specific wagon according to its identity number kept track of and moved about as ordered by control, but the latter knows also the contents of every wagon of coal, what colliery it is from, at whose order it is standing, and what is its destination.

When properly understood, it presents a very pretty piece of organisation machinery to the onlooker, who may see as he stands in the office every train between the collieries and Hull, all the many shunting engines (probably when in full work never less than twenty-five at work at once in the Hull yards) moving their wagons hither and thither, and many series of cards or blank forms constantly changing, but through which at any moment the whereabouts of any consignment of coal may be identified and dealt with.

Needless to say, the forms and returns which convey information to the several controllers in charge are varied and many, although we propose to illustrate with but one series, i.e. that dealing with coal on the way from collieries to Hull, reproducing two of the forms involved in this particular operation.

The s.s. *Mesopotamia*, let us say, has ordered 700 tons of coal from Colliery A.B., 300 tons from Colliery C.D., and 500 tons from Colliery E.F., and she is expected in dock on July 1st, a week after the order for coal has been placed. The controller (stocks section) receives a copy of the order for coal, and as the vessel is not ready for its load, he " files " the order to await attention when the vessel arrives, the commercial clerks in the control office having first card-indexed the order and the particulars it includes. In due time the s.s. *Mesopotamia* is reported by the dock superintendent as now entering, and immediately a " shipping order " form for vessel *Mesopotamia* is made out and placed on a rack in a conspicuous position in the office ; this rack really contains the orders for all coal that is in process of conveyance, and the requirements of every vessel berthed can be obtained from the same documents.

It constitutes a sort of frontier line between the commercial and operating departments : for it represents traffic under conveyance, and it is the working foundation for the controller in the movement of trains, and at any moment the commercial clerks who have to answer merchants' or traders' enquiries can consult the documents here displayed in due order and obtain such information as they need. The documents here referred to consist principally of two ; the " Shipping order,"and that setting out " Coal required at —— Dock " at specific times during each day. These forms are set out in Appendices II and III.

There is also a form on which is recorded in connection with each large order for shipment the precise position of each wagon supplied to the order either at colliery, or on the road, and if so where located ; or awaiting its turn at Hull at —— sidings. This form is being constantly altered to keep it true to current time. By the tabulating of this information, if any detail as to the precise position on the line of any wagon or wagons of a specific shipment order is needed, it can be ascertained at once by a reference to the control board.

As we appreciate the function of these two returns or forms we obtain an interesting presentation of the whole function of traffic control. But when it is pointed out that the order forms on hand at any one moment may run into 100 or 120 or more, and that the information is continually changing with the movement of traffic, some idea of the extensive nature of the work involved to keep everything up to date may be realised.

So far we have been emphasising that the Hull control office is primarily for the purpose of traffic control, but various train-working arrangements have also been allotted to the office. The controller arranges, for instance, the supply of engines and men required to work additional trains from the collieries. It is also his function to watch the hours of the trainmen, and to assist in the arrangements for relieving men when necessary. These functions are, perhaps, in the nature of train arrangement rather than train control, if by control we keep in mind the manipulation of trains along the railway running tracks.

At every control office, whether of trains or of traffic, there is found convenient machinery for taking stock of wagons at the concentrating points or stations, and at Hull amongst other returns that are required daily are: (1) a series of returns every morning showing the stocks of coal required at each of the docks during the day, (2) the loads of traffic on hand at the various yards requiring to be lifted during the day. The latter return is required every morning and every afternoon.

Then at nine o'clock every morning the controller is required to ascertain from the yard masters particulars of the loading of goods wagons at all points at 8 a.m., so as to find out if there is any deficiency in wagon supply. Also to communicate with the wagon control office as to surpluses or shortages, for the general function of wagon control at Hull, as at other points on the L. & N.E. Railway, is carried out in a quite separate office under the local superintendent.

In order to gauge the position about wagons the controller requires to know what empty wagons may be on their way, and, therefore, at 8 a.m. and 2 p.m. information is received from all junction points setting out what empty wagons are on the way to Hull.

As regards mineral wagons the census is required to be taken at nine o'clock every morning and four o'clock in the afternoon, and again at midnight, so that particulars may be supplied to the controller, who will then take the necessary steps to arrange engine power to get any empties on hand back to Gascoigne Wood, the collecting point for empty wagons on their way to South or West Yorkshire.

We may finish this description of the Hull control office by setting out the main object of this control in the words of the official instructions. Its aim as described is to improve the working of freight traffic and to avoid congestion and delay by:

1. Regulating the arrival and departure of freight trains.
2. Securing better loading of engines and reducing light running, by having all the information of train running and of traffic for removal concentrated at one place.
3. Regulating and keeping as near normal as possible the hours of duty of trainmen.
4. Providing reliable information regarding the handling of freight traffic.

It is particularly important to note also the instruction that it is not intended that yard masters or others should be relieved of any duties or responsibilities in connection with the regular working of booked or programmed trains, especially in view of what is set out on the general question of responsibility in a later part of this volume. On the other hand, yard masters, station masters, and other staffs generally, who are associated with traffic working, are called upon to co-operate with the control office to the fullest extent and to render all possible assistance.

MAIN LINE CONTROL

LONDON & NORTH EASTERN RAILWAY

At the beginning of 1923 the L. & N.E. Railway brought into operation a main line control system operated from the central office at York under which the whole of the main line railway as between Doncaster and Newcastle was brought under telephonic train control. This is the most extensive system on the L. & N.E. Railway, and covers 112 miles in the very centre of the system, and comprises a section more dense with traffic than any other in the north-east of England.

The main object of this main line central control was to give better oversight over the working of trains on the main East Coast line (passenger and goods), with a view to getting them to run more punctually and expeditiously, and to provide a central office in which information as to trains and traffic working could be centralised and readily made use of or supplied to any officers who required it for traffic or train working purposes.

The main features in equipment of this control office are: (1) a geographical board, vertical in position, which has the whole of the running lines under control set out, whilst below this board is a long table equipped with three telephonic switchboards each representing a section of the line. These three control sections are as follows, and the sub-section set out under each represent a division of line given effect to on the control board. Of these there are eight, i.e.:

> DONCASTER—YORK: Shaftholme Junction—Selby; Selby—York. YORK—DARLINGTON: York—Thirsk; Thirsk—Northallerton; Northallerton—Darlington. DARLINGTON—NEWCASTLE: Darlington—Ferryhill; Ferryhill—Durham; Durham—Newcastle.

Then at one end of the office there are two controllers whose main business is to receive information about traffic from the different marshalling yards and forwarding points, and to consider and consult the superintendent as necessary with regard to the making up of trains.

The above two main divisions between the controllers in the office having charge over running lines and yards respectively may be taken as representing train working and traffic control separately.

At the train control board tables there are three assistant controllers, each of them having one of the telephone exchanges, so that there are five assistant controllers in all at work: two dealing with traffic and mainly in consultation with the marshalling yards, and three dealing with trains and always in direct consultation with station masters or signal cabins.

Then there comes the special feature of the York control office, which is an ingenious contrivance, and somewhat novel, a moving belt or rather set of belts driven by electric clock mechanism which form part of the equipment of the control board. These moving belts are controlled on parallel lines, each one at a different rate, the rates representing speeds varying on an average from 15 up to about 50 miles per hour, the ticket for each individual train being fixed on the belt that corresponds with its speed. For instance, an East Coast express train coming within the area at Doncaster would be fixed on the fastest line, and would be continuously moving along the line, passing the various stations shown on the board in the background, corresponding with the actual facts of its running. The advantage of the moving belts is that the trains are themselves actually moving along continuously instead of having to be pegged forward by the controller as each one passes a control point. When the main line express gets to York and is timed to wait 10 minutes there, the ticket is taken off the belt and hung up on the board at the York indication, being replaced on the belt when the train starts away again, information being received by the controller immediately by telephone. It is found for all practical purposes that the five speeds graded at 15, 25, 35, 45, and 55 miles respectively give a sufficient range to meet the requirements as they exist in fact. The train tally is, of course, fixed upon the belt that is moving at a rate representing the speed (average) of the train it stands for.

The mechanism under which the five belts which reflect the train speeds is actuated consists of a clockwork arrangement actuated by electric current, and having five different-sized pulleys attached to give the belt speeds as has been described, the driving arrangement being behind the board. A picture of the pulley mechanism which regulates the five speed belts is given in Fig. 13, and the five belts upon the board will be recognised in Fig. 14. In front of each of the control operators is a clock, the clocks in the control room being synchronised by a master clock.

When the writer visited the office he had travelled from London by the ten o'clock train due at York at 1.45 p.m. Visiting the control office 20 minutes after arrival, the train was already 12 minutes on its way northward, and was half-

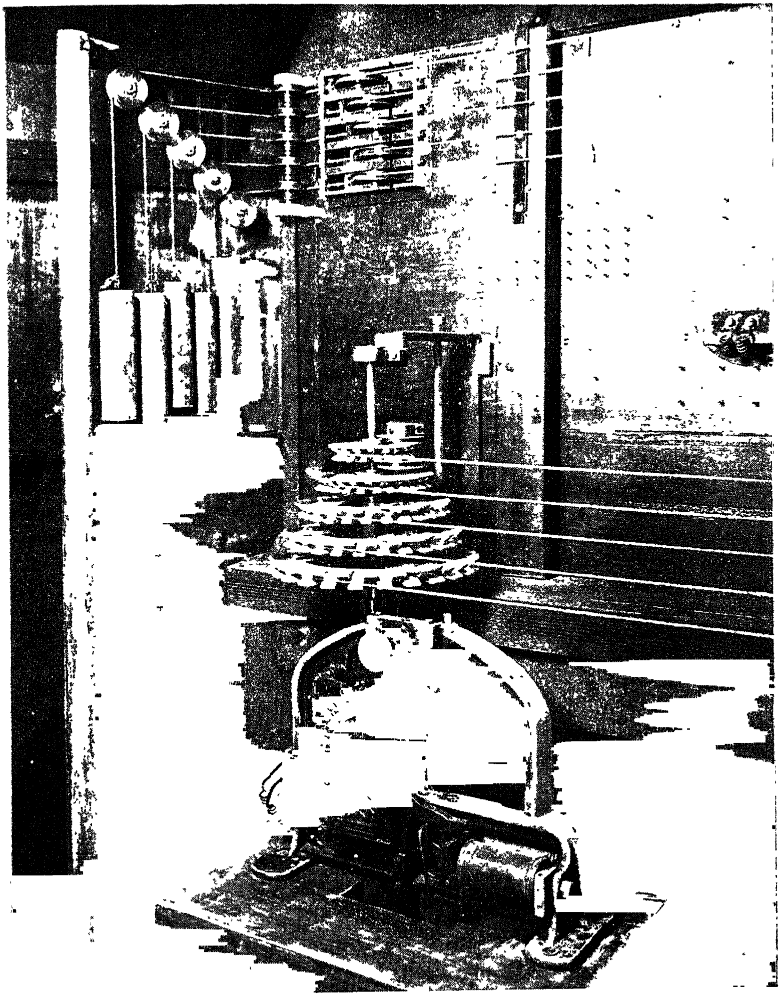


FIG. 13.—YORK CONTROL OFFICE: PULLEY MECHANISM WHICH REGULATES THE FIVE SPEED BELTS.

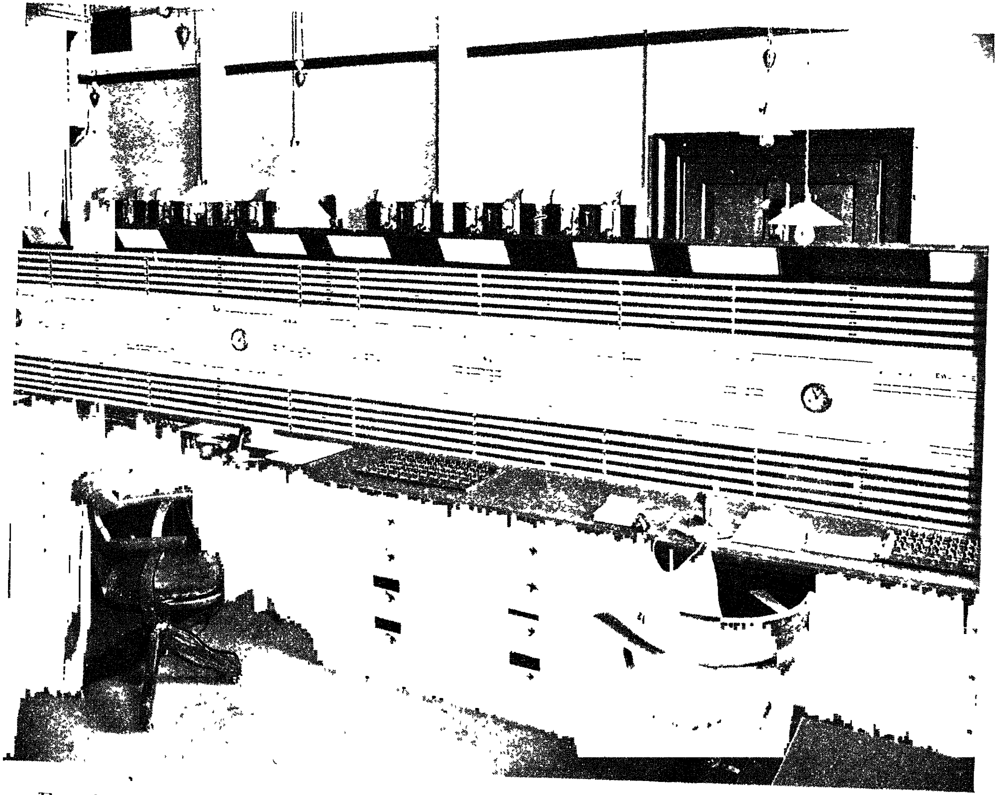


Fig. 14.—York (L. & N.E.R.) Train Control Board, showing Five Moving Belts and Controllers' Chairs and Telephones.

way between Beningbrough and Tollerton stations, 8 miles north of York. The record on the train sheet showed that this train had arrived 2 minutes late at York, and left for the North also 2 minutes late. This train sheet gave the complete record of the train's load and performance since it left King's Cross. This sheet we will now describe.

One function carried out in the York office is that of recording main line passenger trains. Every principal main line train is recorded on a train running sheet which the controller keeps in front of him and enters up as the train is running, so that at the end of each day he has a record of the running of the trains showing " to time," or " minutes late " at each station at which it is booked to stop, and the make-up of each train, i.e. the number of carriages at each section of its journey. The forms on which these records are made up are given in Appendix IV. The principal freight trains on the main line are also recorded on similar sheets as the trains pass the various points (Appendix V).

This recording of trains in the central office is of great advantage. It saves the necessity of subsequent looking through of the guards' journals, and at a later period of inquiry as to the meaning of detention. All this train running work may now be done in the control office currently with the working of the trains.

Three illustrations are given showing the interior of the York control office: Fig. 14 (page 127) illustrates the main control board with its five moving belts (up and down respectively), the line and various stations *en route*, and the chairs and telephone instruments used by the assistant controllers. Fig. 15 (page 128) shows on a rather larger scale a section of the board representing York and the lines to the immediate north and south.

Fig. 16 (page 129) shows the section of the office allocated to the traffic controllers, who are in constant telephonic communication with the foremen of the various shunting yards.

It will be noticed that at the frontier point at each of the eight sub-sections there is a gap on the control board which indicates that here is a terminal or intermediate station at which a train may stop at the station or in the sidings. These frontier points are at Selby, York, Thirsk, Northallerton, Darlington, Ferryhill, and Durham, and when, as is the case with most goods trains, the train leaves the running lines and enters the siding, the token is taken off the line and hung up on peg hooks provided on the board at the station in question. A glance at the board always shows, therefore, whether a train is running on the main line or is in the station siding. Moreover, the controller keeps a careful eye on the time occupied at each station to see whether a goods engine is being detained in the goods yard sidings longer than it should be, and if it is he immediately enquires the reason why.

When a train gets out of course and cannot leave its station at booked time, it is kept back until an appropriate path can be arranged clear of other trains, and this path is determined by reference to a train diagram showing the trains running daily on each section which is on the same lines as described in connection with the L. M. & S. control office at Derby (Appendix VII, facing page 248).

We have described the train record and train running supervision functions carried out in the control office. In addition to these main functions the control office is charged with the duty of relief of the trainmen when necessary, and of seeing that they do not work longer hours than they should. The control office has not as yet, at any rate, brought under its supervision the recording of the weights of trains, nor is it charged with any responsibility in connection with the distribution of carriages or wagons. These functions on the L. & N.E. Railway are carried out in separate offices, known as the carriage control office and the wagon control office respectively, and in these two offices the supervision of carriage and wagon stock distribution is vested independently of the train control office, as explained later.

On the other hand, the fact that the two assistant controllers who deal with traffic, indicated on page 125 as controlling the traffic, and known as traffic controllers, are located in the control office, indicates that much of the responsibility of supervision of the marshalling yards is shared by the controllers, and to this extent the yard masters or yard foremen in the respective yards are assisted. They are in constant consultation with the traffic controllers, whilst the principle is recognised of leaving with the men on the spot, i.e. the yard foremen, as much responsibility as possible.

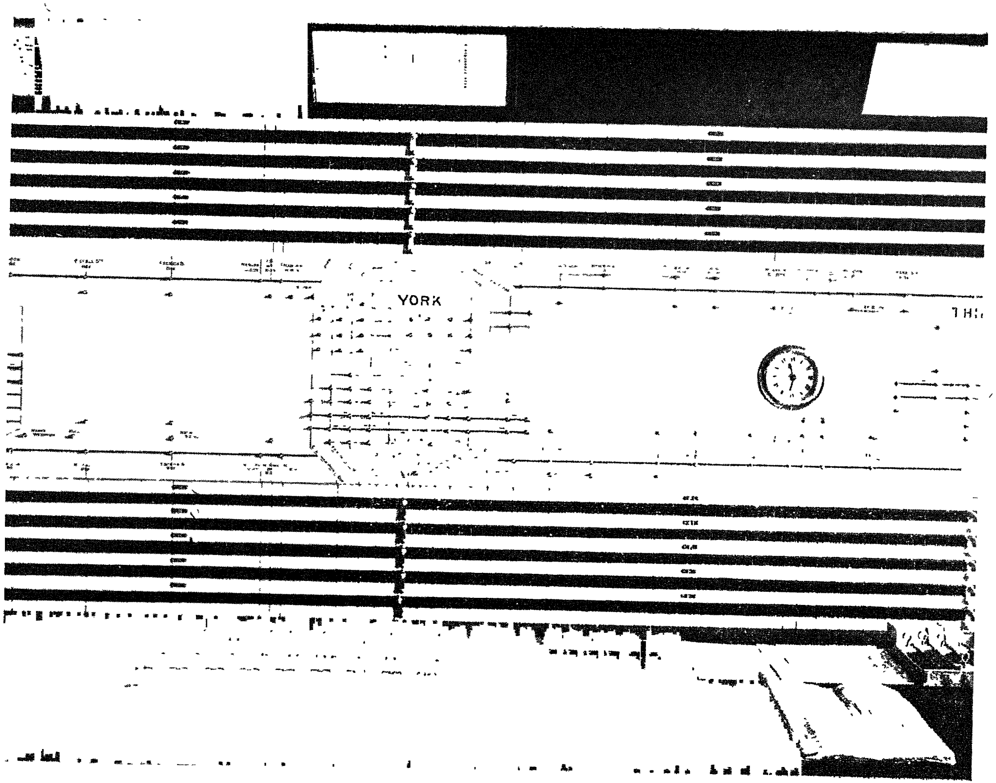


FIG. 15.—YORK TRAIN CONTROL BOARD SHOWING SECTION OF BOARD, IN VICINITY OF YORK.

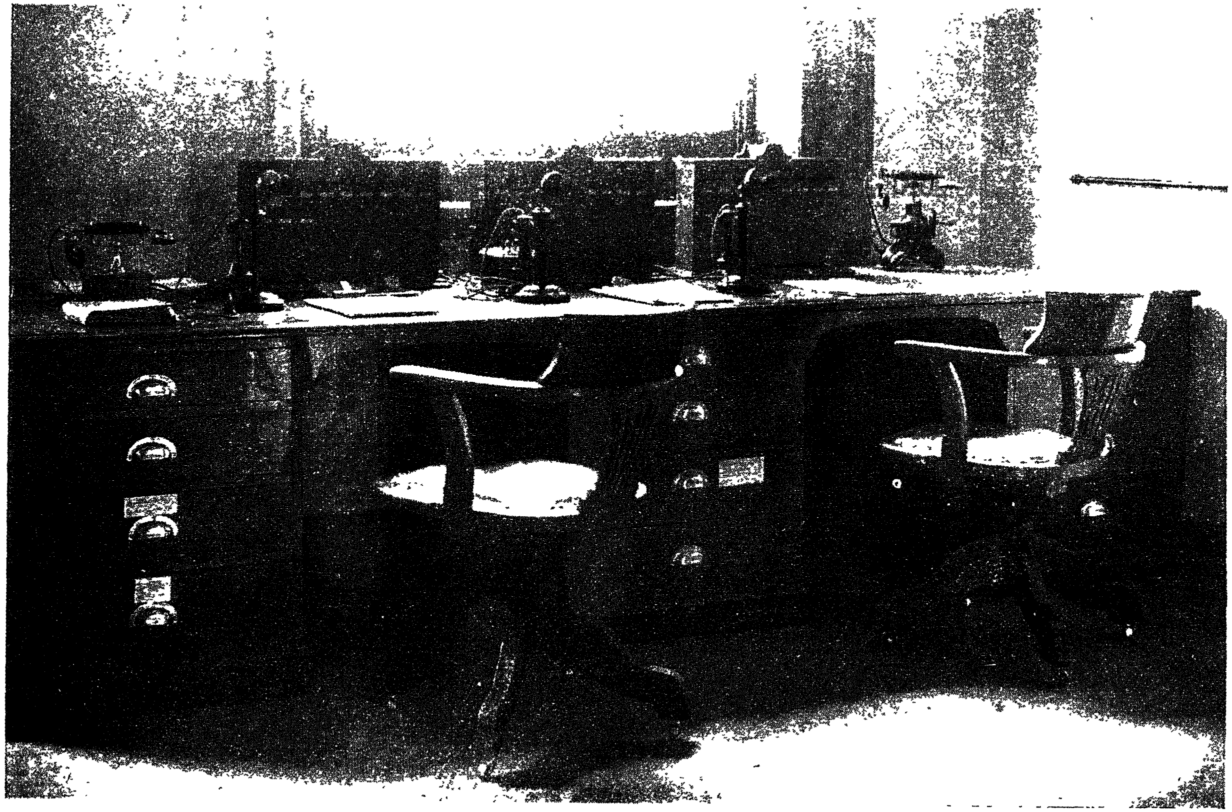


Fig. 16.—York Main Line Control Office: Traffic Controllers' Desks.

It may be well at this point to illustrate how the question of responsibility works as affecting the signalmen. This is a point that has several times been referred to, and will be again, as it is of prime importance. A signalman, say half-way between Darlington and Northallerton, has a goods train running on an independent line, and if a main line passenger train which occupies the rails required by the goods train going south is running 15 minutes late, he is not quite sure whether it would be right, having regard to the narrow margin, to allow the goods train to go on to its next stage, Northallerton. If there were no controller to consult, he would not take the risk, but would hold the goods train back, causing further delay to it and contingent trains. With the control office in existence, the signalman will consult the controller, who, with his greater knowledge of the whole system, will most likely be prepared to take the risk and authorise the signalman to despatch the train. The controller will take the responsibility instead of the signalman, but he does it with much greater knowledge of general arrangements and train running. It would seem clear from this that on the aggregate of the day's working many trains are worked forward a stage under "control" responsibility which in the old pre-control days would have had to be held up because the margin for clearance was not considered sufficient. This no doubt is the real fact.

CHAPTER XI

THE OLD LANCASHIRE AND YORKSHIRE RAILWAY METHOD

It is proposed in this chapter to describe the arrangements adopted and the methods employed at the control office at Victoria Station, Manchester, in connection with what used to be the Lancashire & Yorkshire Railway system (now a section of the London Midland & Scottish Railway system).

We have already described in some detail the arrangement put into operation in the Middlesbrough and Hull districts of the L. & N.E. Railway for the control of the freight trains in those areas of dense freight-train working, as well as the main line train control on the East Coast route to Scotland. The Lancashire & Yorkshire Company as from August 1915 adopted a central telephone control office for their freight trains at Manchester, which was soon extended over the whole of their railway system, stretching from Liverpool in the west as far as Goole at the eastern side of their territory, and from Hellifield in the north to Warrington in the south.

The most conspicuous feature of this L. & Y. control was probably, and still remains, the excellent control board; and the main aim as defined was (1) to work the freight traffic of the Lancashire & Yorkshire system in as economical a manner as possible, that is with the lowest expenditure of engine power, and (2) to provide an efficient means of keeping the trainmen's hours within proper limits. This is much the same, as we shall see subsequently, as was the aim of the old Midland Railway when they commenced to work a "control" system. Various other purposes were served as soon as the apparatus was installed, and these will be referred to one by one; but we may first describe the methods and appliances adopted.

Let us describe the apparatus. We have spoken of the excellent control board as the most conspicuous feature. The importance of an adequate and efficient board will be appreciated when it is realised that a main principle of the system is that no train movement takes place within the control area (that is the running lines of the L. & Y. Company's system) except with the controller's authority, and therefore he needs some means of visualising hour by hour the trains under control.

The provision of a control board for the whole area of the L. & Y. system is a different matter from the installation of such a board as that in the Middlesbrough area, where the distance covered is about 35 miles from east to west. The L. & Y. control board is as described below. A circular room having been built for the purpose of containing the staff and equipment, the inside wall was divided into seventeen sections, each section representing one control district of the L. & Y. Railway system. It was not divided upon any fixed number of miles per section, or with any arbitrary or mathematical precision. Regard was necessarily had to the varying character of the districts : a district of light traffic like that between Colne and Hellifield is very different from the Liverpool and Manchester area ; and where there are a number of marshalling yards the questions of control arising are very different from those of a straight run of main lines free from concentrating points.

Each of the sectional maps or boards would comprise, say, from 50 to 150 miles of running road, and at the busiest time of day on each section there might be up to fifty or sixty trains or engines working at one time.

The accompanying illustrations show two sections of the control board maps on the wall, Fig. 17 showing No. 4 sectional area (Wigan district). It has been pointed out that there are seventeen of these sectional maps round the circumference of the room. It will be noted in the pictures that there is an upper wall map, above the dado, as well as the lower section-map. The upper map is a combined map bringing together the whole of the sectional areas into one. This will be explained at a later stage. Fig. 18 shows the upper wall combined map and the chief controller's desk.

On the sectional boards or maps are marked every running line, and every independent or running relief siding, every station and signal-box, every marshalling yard with its sidings, and every engine running shed. Every moving train or engine in the area is under control; it is therefore essential that the area be clearly defined. Each train or engine is represented whilst "in traffic" by a peg or token on the board so as to be visually under the supervision of the controller. It is laid down in the regulations that *no train movements within the area are to be made without the instruction or permission of the controller.*

The main instrument of the control installation is an efficient telephone system: for any large area of control over running trains a satisfactory system of telephone communication is essential. The only reliable method is to have independent telephone circuits allocated entirely to the control supervision; and this telephone system should provide two separate circuits, one for direct communication with local control points in the current working of trains, and a second to give direct communication between all the district controllers and headquarters for purposes of conference or general communication with the centre.

In the Victoria Station (Manchester) control arrangements each of the seventeen districts has a separate telephone circuit with its exchange or switchboard at a table in front of the control map, and at which the controller in charge sits. This gentleman, the controller of the district, is therefore in constant communication with the men on the spot where the trains are running, and as each train passes the local control station—usually a signal-box—the peg or token is moved to its corresponding position on the map. When a train passes out of one area and into the next, the peg is taken off the board and a similar peg is fixed in the adjoining control board, the operator in charge of the latter taking up the responsibility for further watching the train and pegging forward its progress as he receives news of its travel by stages from the local control points.

We are dealing, it must be remembered, with freight trains—a coal train, it may be, from the Pontefract (West Yorkshire) neighbourhood required at Liverpool by a specified time; or a stopping goods train for local service between Manchester and Rochdale. In the former case the controller has to keep watch upon the working of the train to secure its passage over the route as nearly to the arranged time as is possible, taking care that it causes no detention to passenger trains on the one hand, and on the other that every possible margin between passenger trains is taken full advantage of.

In the case of a local service train as between Manchester and Rochdale, a goods train will have much attaching and detaching of wagons to do at each point of call, including calls it may be at two or three private factory sidings.

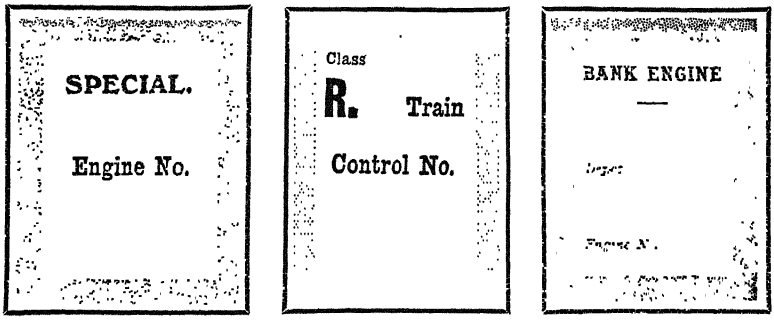
These wayside stoppages involving shunting of wagons are the occasions where in goods train working so much time is apt to be lost from a great variety of causes: it is under these circumstances that so much depends upon the smartness and ability of the driver in charge. And it is a new feature in modern goods train working for the trainmen (enginemen and guards) to have to realise that the eye of the supervisor is always upon them, never mind how far they may be from a station or from their home base. It is equally a terror to the slack or careless servant and a matter of encouragement to the efficient and loyal ones.

This watching of the time taken by goods trains in the performance of their station and shunting work may be reckoned as one of the principal duties of the controller in direct train supervision. If there is an extra amount of work to do at a station on any occasion, and the train takes 10 or 20 minutes longer than its scheduled time, it is manifest that it cannot maintain its normal running hours on the main line, and the controller will then be concerned with securing for it the best running "path" to its next stopping place.

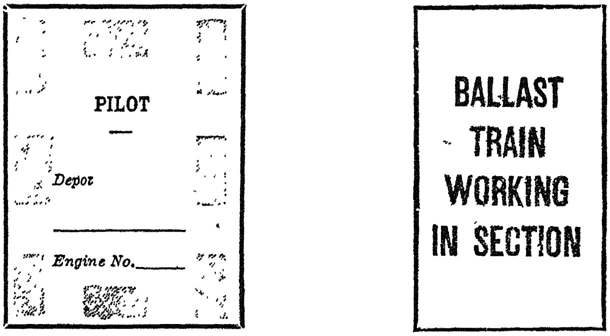
We have spoken of a train on the board as a peg or a token. But the controller needs to know something more about the train than the simple fact that it is a train. Is it a goods or coal train? What sort of a load? Who is in charge?

Whilst a system of colouring of the pegs or the shape of them (round, square, diamond, etc.) provides a simple indication as to certain differences, e.g. a fast or a slow, a goods or mineral train, the controller needs more information than this. So the peg is supplemented by a card or ticket.

This ticket can be kept in a special cabinet constructed for the purpose and numbered to correspond with the peg, or it can actually be fixed with the peg on the control board. As a matter of fact, a combination of these two methods is adopted at Manchester : each ticket has a margin line of colour to show



Margin brown. Margin pink. Margin blue.



Margin red where shaded. Circle in centre red.

Fig. 19.—Samples of Tickets which are used for the Control Board to Indicate the Trains and their Work, Manchester Divisional Control Office.

generally what is the description of train, whilst the printed or written contents of ticket provide for the identity number of the train as per working instructions, the class of engine, the technical classification of train, and the points between which it is working.

Some of these tickets or control tokens are set out above. These small tickets with coloured margins representing the various trains fulfil in the Manchester office the same purpose as the tickets or labels which in the Middlesbrough office were placed in a clip acting as rider upon the lines of the control board. (See Fig. 12, page 112.) It would be well to compare the two systems: the tickets shown in Fig. 19 represent respectively a bank engine, an ordinary train, a special train, a ballast train working in a section, and a pilot engine.

As each set of trainmen commence the day's work, their names and hour of commencing are telephoned to the control office, and a working sheet is there made out of each guard's work, showing the trains he has been working during the day with the time occupied upon each.

A card or ticket in respect of each guard and engine crew is handed to the trainmen's controller in the central office, and these cards are sorted in time order, so that as every man's duty attains the completion of an 8 hours' shift, arrangements are at once made to relieve him and a new man is provided.

Wherever this system has been installed it has proved effective in bringing down the working hours of trainmen to normal limits, so that at present there is very little ground for complaint on this score.

Let us now continue the description of the physical arrangements and staffing of the office.

Seventeen section controllers (three of which, on account of the large size of district, have assistant controllers) sit round the room, each with a separate telephone exchange and table, and a map of his particular district in front of him.

In an inner circle of the control office sit the chief controller, the three deputy chief controllers, a rolling-stock controller, a coal-traffic controller, six controllers for guards' and enginemen's relief, and about three relief controllers (for relief of those on holidays or sick leave). There is one man in responsible authority over the whole office known as the control master. Practically all these men are 8-hour shift men, and the numbers given represent one shift, so that they must be multiplied by three to get the full strength of the office.

The control master, or chief controller, is a highly efficient official, whose main duty is to watch the working of the whole mechanism and be prepared to advise what should be done under any circumstances of difficulty or emergency.

Reference has already been made (page 131) to the map on the upper walls of this circular room. This is a combined map of the seventeen sectional maps, and so comprises the whole area of the Lancashire & Yorkshire system. It is most ingeniously arranged, and at every local control point in the area a coloured light flashes whenever a train is in that particular local section. It is automatic in its working, and being a replica of the district control maps is so arranged that as a train is pegged forward on the sectional board it automatically actuates the light on the combined board. These lights are of five colours :

A red light indicates a train on the down line.
A white light indicates a train on the up line.
A purple light indicates a train on the up loops.
An amber light indicates a train on the down loops.
A green light indicates a train on the sidings.

So by this automatic mechanism the large comprehensive board indicates by these miniature coloured electric lights the position of every goods train working at any moment on the whole L. & Y. system. It is a visual geographical epitome of all the trains on the system under control.

As already stated, the L. & Y. system of train control at Victoria does not deal with passenger trains. It is a goods train control scheme, and as such very efficient.

In considering the function of central train telephone control, it is a matter of much importance to keep clearly in mind the following separate functions which are often relegated to or assumed by the control office when established :

(*a*) Supervision of goods train working.
(*b*) Control or regulation of trainmen's hours, and arrangement of relief as necessary.
(*c*) Distribution and control of goods wagon stock.
(*d*) Supervision of passenger train working.
(*e*) Distribution and control of passenger carriages and stock.

(*f*) Allocation and control of guards' vans.

(*g*) Control and distribution of locomotive power.

(*h*) Working in marshalling yards and allocation of shunting sidings.

(*i*) Recording of goods train working.

(*j*) Recording of passenger train working.

A central scheme of telephone control may combine all the above, or any one of the functions, or any combination of them ; and in accordance with the functions contemplated or arranged for the office must the particular organisation be adapted.

The organisation and arrangement of duties in the general and district superintendent's offices are likely to be largely affected also.

It will be suitable here to take the specific functions above named and consider in each case the extent to which —if at all—they have been assumed by the control staff in the Manchester office. We have seen that in the case of the first two items (*a*) supervision of goods train working, and (*b*) control and regulation of trainmen's hours, they have been adopted as the principal work of the control office ; these, indeed, are the functions generally understood to constitute the main *raison d'être* of any central control office.

The placing of these duties under a controller takes away a large portion of the pre-existing work of the "trains section" of the superintendent's office, and in a case of this kind it will usually be found desirable to transfer and employ some of the train clerks to the new office.

(*c*) *Distribution and Control of Goods Wagon Stock.*—This subject and the general question of control of wagons is dealt with in Chapter XVI, and as we realise the very complete organisation that exists and has for long existed for the distribution of the wagon stock of each company, it will be understood that a very heavy additional responsibility is imposed upon the control office if and when it takes up this additional function.

In the Manchester (Victoria) office the wagon control function is combined with that of train control, and given effect to by the same system of telephone wires ; the controllers of each district at certain fixed times of the day ascertain the position of the district as regards wagons, with a view to fixing the needs of to-morrow. The principal daily census is taken at 4 p.m., when every district controller receives a telephonic report of the number of wagons on hand at each station, the number of spare vehicles, and the number required for to-morrow's traffic. The returns so ascertained from each district are transmitted to the wagon controller in the central office, whose work is a section of the general control office, and all adjustments as between district and district are given effect to by him ; and the surpluses in the district are at once collected and removed to such other points or stations as are in need of supplies.

The fact that these daily adjustments and allocations of empty wagons are made by the same authority, or at least in the same office, that has the responsibility for the train movements on the line is of great advantage, for the empty wagon movement can at once be given effect to by those who understand how to get the distribution made in the most economical and expeditious manner and by machinery which is in constant contact with the various stations whose needs are to be supplied.

The rolling stock controllers are on duty regularly from 6 a.m. to 10 p.m., working in two shifts.

(*d*) *Supervision of Passenger Train Working.*—Passenger trains are not brought under control at Manchester control office in any sense such as obtains with goods trains, or as main line trains are supervised from Derby. They are not pegged up on the control boards. They run in accordance with the published time-tables, and their occupancy of the main lines in accordance with scheduled timings is the groundwork of all control manipulation of goods and other trains. The latter have to be dovetailed without prejudicing the former.

As a matter of fact, the control office and apparatus at Victoria is used by the superintendent for obtaining his records of the daily running of some of the principal L. & Y. trains ; this is explained later under the heading of "Recording of Train Running."

(*e*) *Control of Passenger Carriage Stock.*—The distribution of extra carriages, saloons, horse-boxes, and carriage trucks, and other vehicles for passenger train working, is also arranged in the control office under the supervision of a passenger rolling stock controller. The organisation of this control of carriage stock will be described in the next chapter in connection with the Derby office control, and it seems unnecessary to describe it in further detail here, as the methods are quite similar.

The complete organisation for the daily allocation of wagons and carriages for a large railway system is specially dealt with in Chapter XVI. Whilst appreciation of the complexity of carriage and wagon control under arrangements as there set out serves to emphasise the additional heavy responsibility that is thrown upon the chief of the control office as soon as rolling stock control is added to his other duties, yet at the same time the arrangements at Manchester (Victoria) and at Derby appear to show that advantages of no small order do, in fact, accrue from a combination of the functions with train control under efficient supervisors.

(*f*) *Allocation and Control of Guards' Vans.*—The distribution of goods and mineral brake vans is in charge of the Manchester control office. The guard's van, like the engine, is so integral a part of train working that whenever central control has been adopted it has carried with it the supervision and regulation of the supply of guards' vans.

Twice a day, viz. at 7 a.m. and 5 p.m., a report from all stations concerned is received by control giving particulars of brake vans on hand, and the controller then takes in hand such adjustment as may be necessary to bring the vans to the places where they are wanted for subsequent working.

(*g*) *Control and Distribution of Locomotive Power.*—A very full control over locomotive engines is essential for any satisfactory train control system. A controller must be able to order out an additional engine whenever required : and when a set of enginemen have completed their 8 hours, the controller must have authority to send them home and replace them with a fresh set of men. The organisation in the Manchester office is in this wise. There is in the office a locomotive controller who is always available for consultation in case of anything being wrong with a locomotive whilst at work. He is consulted on all questions affecting the mechanical side, or on any question of reducing or increasing the engines at work. As an additional engine is found necessary, the deputy chief controller on duty at the time signs an order upon the locomotive department to send out a fresh engine.

The total engine supply on the old L. & Y. area is, apart from engines under repairs, at the call of the traffic department as required; but a check upon the number of extra engines ordered out is kept by means of a return from the "Ordering of Engines" book, which is carefully examined day by day, or as found desirable by the head of the department.

(*h*) *Working and Control of Marshalling Yards.*—Whether the control office should have any direct jurisdiction over the working of marshalling yards or not is, and is perhaps likely to remain, a matter of some controversy. It must very much depend upon the degree of authority vested in the controller by the general superintendent.

If the controller of a sectional control office is given a position in any respect like a district superintendent with the authority of a district operating officer (though this was not the case under the L. & Y. régime), he will require to bring the marshalling yards under direct supervision. If the control office staff is, as in most cases, simply a train running supervising office, it will not need to undertake direct supervision over the yards. It does not do so in the case of the Manchester office; here, when a train enters a marshalling yard, its token or ticket comes *off the control board,* and for the time being the train is under the entire direction of the yard master in charge. It is again brought on to the board on the resumption of its journey.

In some control offices, as e.g. at York, provision is specifically made for trains when shunting at a marshalling yard and for the time being out of control to be watched or controlled by an assistant controller, whose one function is to keep in touch with the traffic and circumstances of the marshalling yards. See page 128.

Although the prime responsibility of yard working remains with the yard master or foreman on the ground, and the superintendent will look to him for the most efficient and advantageous utilisation of the several yard sidings, the controller takes a continuous and sympathetic interest in the arrangements of the yard, and is ever ready to make helpful suggestions, as he is from the nature of his train supervision constantly kept aware of the general condition of the yard working, and knows whether it is getting congested, and very often knows also the best way of obtaining relief by some rearrangement of shunting or making up of trains.

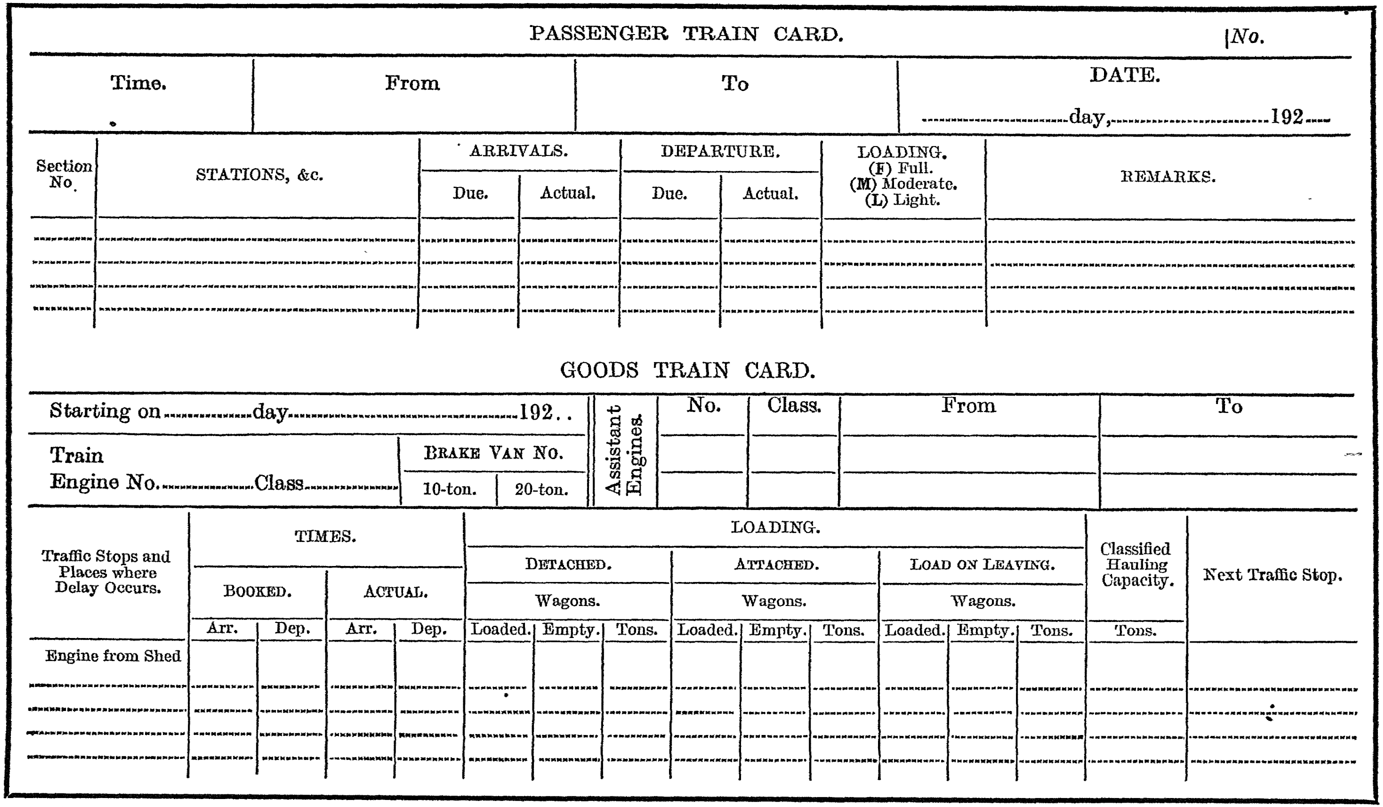
The relationship between the busy marshalling yards and the control office has been dealt with in considerable detail in connection with the L. & N.E. Railway control at York (Chapter X) and in the chapter upon "Responsibility."

(*i*) *Recording of Goods Train Running.*—The recording of train running is really a sequel to and the counterpart of the general supervision of train working—the first function of any control office. Full particulars as to time of arrival and departure, and of wagons attached and detached with load in tons or in wagons wherever practicable, are transmitted by 'phone from each station and control point; and all these particulars are immediately entered upon forms provided for the purpose. So the control office of the superintendent comes by this method into possession, currently with the working, of all the information, and more, which the previous "trains offices" tabulated from the guards' journals at the end of each week or month as the case might be.

(*j*) *Recording of Passenger Train Running.*—Although passenger trains are not dealt with on the control boards, their running can easily be watched when necessary, and indeed must be watched for goods train working purposes. So it is found of advantage to use the control office machinery for the purpose of obtaining records of the running of all principal passenger trains.

Two of the forms used for passenger and goods train running records are set out on page 142, and signalmen have instructions to transmit to the control office all the running times and any other necessary particulars to enable these forms to be properly filled up.

The blank return is in the form of a card, and the control office is supplied with these cards daily for each train in respect of which the superintendent requires his records. At the end



PASSENGER TRAIN CARD. |*No.*

Time.	From	To	DATE. ……day,……192……

Section No.	STATIONS, &c.	ARRIVALS.		DEPARTURE.		LOADING. (F) Full. (M) Moderate. (L) Light.	REMARKS.
		Due.	Actual.	Due.	Actual.		

GOODS TRAIN CARD.

			Assistant Engines.	No.	Class.	From	To
Starting on……day……192. .							
Train Engine No.……Class……	BRAKE VAN NO.						
	10-ton.	20-ton.					

Traffic Stops and Places where Delay Occurs.	TIMES.				LOADING.									Classified Hauling Capacity.	Next Traffic Stop.
	BOOKED.		ACTUAL.		DETACHED.			ATTACHED.			LOAD ON LEAVING.				
					Wagons.			Wagons.			Wagons.				
	Arr.	Dep.	Arr.	Dep.	Loaded.	Empty.	Tons.	Loaded.	Empty.	Tons.	Loaded.	Empty.	Tons.	Tons.	
Engine from Shed															

FIG. 20.—COPY OF BLANK FORMS ON WHICH TRAIN RUNNING (ARRIVALS AND DEPARTURES) IS RECORDED, IN THE CASE OF TRAINS DEALT WITH IN THE DIVISIONAL CONTROL OFFICE, MANCHESTER.
(*a*) Passenger Trains. (*b*) Freight Trains.

of each day these cards are collected and sent in to the superintendent, and from these daily records he can review the running for each month or shorter period as he thinks fit.

The mere description of this process seems on the face of it to carry with it a suggestion as to whether these returns may not be deemed to supersede much of the work now incurred in filling up the guard's journal—to suggest, indeed, the possibility in the future of abolition of guards' journals in their present form.

CHAPTER XII

THE LONDON, MIDLAND AND SCOTTISH RAILWAY CENTRAL CONTROL AT DERBY

It is to the London, Midland and Scottish Railway that we must give the main credit for the extension and consolidation of a central control system of train working over a large area. We have referred (page 97) to the comparatively small beginnings of telephone control on the Midland Railway when Mr. Cecil Paget, as superintendent, fixed up his first office and apparatus to regulate and control the goods and mineral trains in the Masboro' area. At Masboro' as a centre in July 1907 the despatch of the coal trains from the collieries and the staging of them from point to point on their way south towards London, or on their way to Hull and Grimsby for shipment, were carefully regulated. Colliery owners were no longer allowed to send forward their trains of coal on to the railway system until it was known that the vessel they were to be shipped into was ready to receive the cargo; nor was any train of coal or goods received on to the line from a colliery siding except at times when it was known that a clear path through to destination could be arranged: the result was the restoration of comparative order where there had been for some years much of haphazard working leading to most serious congestion and inordinately long hours of duty for the trainmen.

The main factor in this new venture was an efficient system of telephones between the supervision office and the signalmen. It was with the aim of reducing the men's long-hour shifts that this complex question was vigorously attacked, and the main function of the Masboro' office when first opened was that of providing relief sets of trainmen to take the places of those who had worked a normal shift (then 9 or 10 hours) in connection with the mineral train working in South Yorkshire, Derbyshire, and Nottinghamshire. The new Masboro' office thus became a relief office for keeping down the hours of the men: by means of a series of cards containing the requisite particulars as to each man's work, time of starting duty, when and where relief was likely to be required, to be filled up by the men concerned, and as soon as filled up transmitted to the Masboro' office; that office watched the men's hours and made the necessary relief arrangements, and it did this with such effect that the district it controlled from being the one most notorious for long hours for the men became the most favoured district from the point of view of hours worked.

It is interesting to note that at the very inception of the control arrangements this point of keeping the men's hours within reasonable limits, which has always seemed to present such difficulties, and which has all along retained a central position in control arrangements, found its solution. The telephone system, however, which was at first provided for train-crew relief purposes, came in very advantageously for use in the general manipulation and supervision of goods and mineral trains; and in 1908 a very considerable extension of the telephone circuits was planned for the purpose of more efficient train control. During that year the whole of the main lines on the Midland between Normanton on the north and Trent sidings on the south were brought under one telephone control, with district or sectional control points at Cudworth, Masboro', Staveley, Westhouses, and Toton. A diagram of this section of line—the first extensive control section on the Midland—is given on page 146. This diagram very well illustrates how the reporting or local control points are distributed all along the route of the controlled area. The full value and utility of the new arrangements were only appreciated after some experience of the working had been gained, and indeed there were many lugubrious predictions as the new system was undergoing preparation that it would prove a vast white elephant; but those who undertake to pioneer are always brought up against this class of sceptical comment, and know how to treat it. Sufficient to say that official records state that whereas in the first half of 1907 there were 24,000 cases of

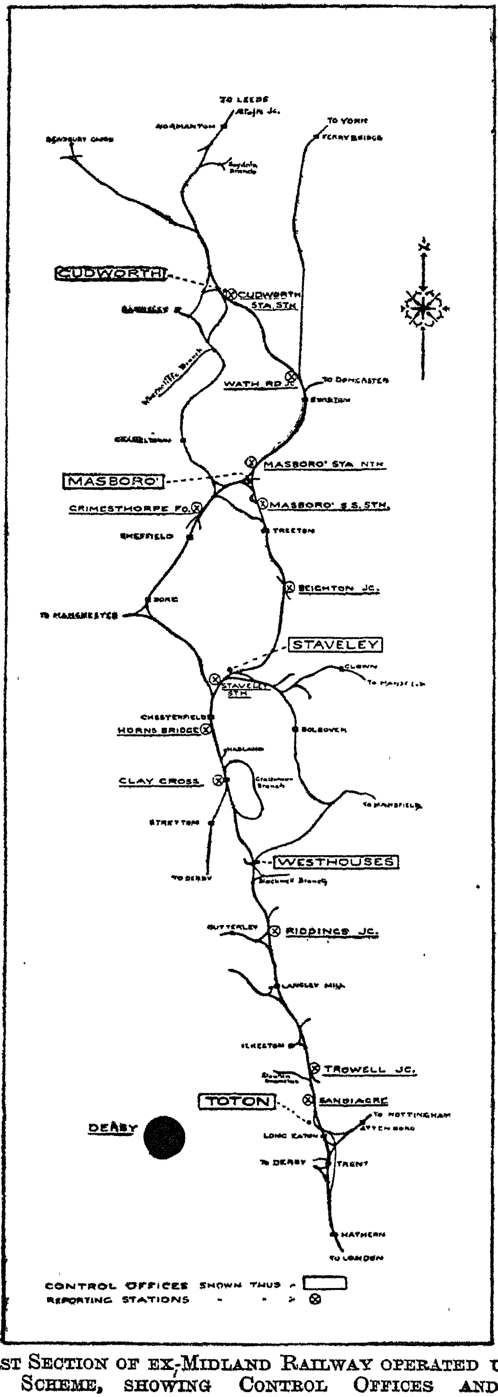


FIG. 21.—FIRST SECTION OF EX-MIDLAND RAILWAY OPERATED UNDER TRAIN CONTROL SCHEME, SHOWING CONTROL OFFICES AND REPORTING STATIONS.

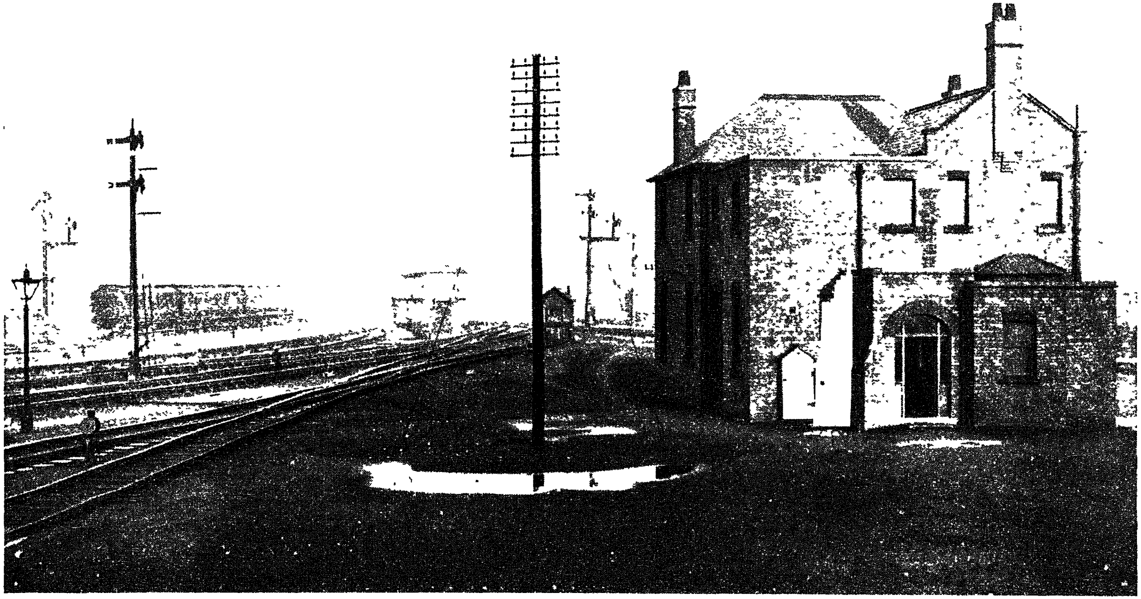


FIG. 22.—EXTERIOR VIEW OF MASBORO' DISTRICT CONTROL OFFICE.

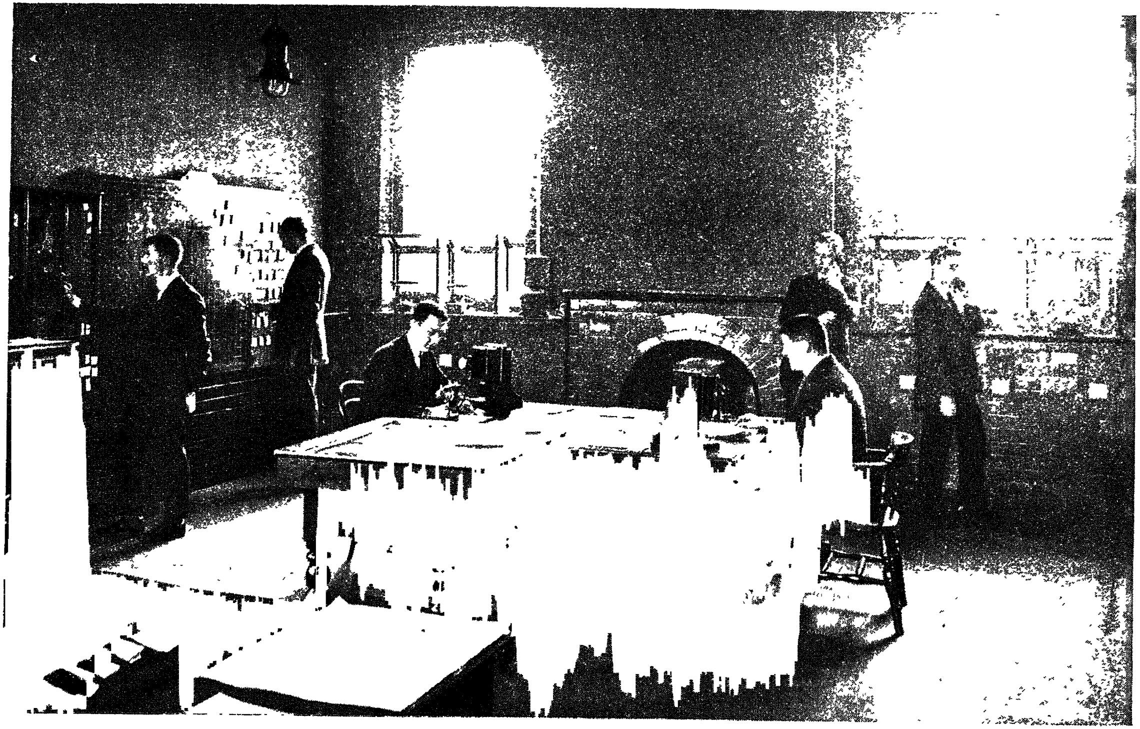


FIG. 23.—INTERIOR VIEW OF MASBORO' DISTRICT CONTROL OFFICE, SHOWING DAY STAFF ON DUTY.

unreasonably long hours on the part of trainmen, the number had been *reduced to nil during the same period of* 1911, when the new relief machinery had been extended over practically the whole line.

Not only were the trainmen's relief arrangements so vastly improved, but also the general train working supervision—so much so that very shortly after this more limited experience the Midland directors agreed to extend the control arrangements over the whole system ; and the Midland Railway then became divided into twenty-five districts for train working and "control" supervision.* Each of these districts has its own control office with an effective telephone system and exchange.

One of the district control offices must first be described, to be followed later with a description of the central office at Derby. The principle of the Midland arrangement is to have the sectional controller *in the district office* in the centre of the actual traffic of the district, in contradistinction to the Manchester (Victoria) arrangement, where all the section controllers and boards are concentrated in the one central office.

Let us take the Masboro' control office as a sample of one of the twenty-five district or sectional control points on the Midland system. An illustration of the building in its exterior aspect is shown in Fig. 22. It is situated only a very short distance away from Masboro' station in the triangle where the line to Grimesthorpe and Sheffield branches off from the line from York and Masboro' to Staveley and south. The main control office being upstairs and well provided with window lights commands a good view of the railway lines and traffic all round.

On entering the office, an interior view of which is shown in Fig 23, an animated scene of some half-dozen officials busy receiving and answering telephone messages, recording information received, and arranging or moving about little paper tickets upon a special control board erected against the wall, presents itself.

There are seventeen telephones in the room giving direct access (1) to Derby, (2) the various reporting points in the

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* These districts have been slightly modified as the result of the 1923 amalgamations of railway systems, but in essence the district control areas remain the same.

Masboro' district, and (3) by means of a special switch at Derby to some 160 stations or sidings or signal-boxes. There is a special extension into the chief controller's own room, so that he himself can converse directly with any of these points as may be necessary.

Next to the telephones, the control boards (of which there are two) are an important portion of the control mechanism; the two boards are necessary for the two sections of line, Cudworth to Staveley and Masboro' to Trent sidings.

One of these boards, viz. that from Cudworth to Staveley, is illustrated in Fig 24. The main part of the board is ruled vertically as a time board, the vertical lines representing 5-minute intervals and the complete series 12 hours, i.e. from 12 noon to 12 midnight, and the converse. There are two columns to the left of the time columns, and three columns at the right-hand side, headed respectively:

> *Left.*—" Out of area." " Traffic waiting to be moved."
> *Right.*—" Shunting engines." " Trip engines shunting." " Out of area."

The horizontal lines represent the principal geographical stations along the line of control, namely:

> Cudworth Station South; Wath Road Junction; Masboro' Station South; Masboro' Sorting Sidings; Beighton Junction, Staveley South.

The general mode of operation is as follows: As soon as a train comes into the control area, say at Cudworth, its counterpart token or ticket is hung on to the board at the time it passes Cudworth, and if it is a train which is steadily passing through the area into the next section at Staveley, the token is moved along the board downwards as it passes each of the five points named above according to the information reported, and as it passes Staveley the token is again taken off the board. If it is a return working train and expected back, the token, instead of being filed, will be hung up opposite Staveley outside of the time columns, as it is now " out of area," and will be placed on the peg in the " out of area " column at the right. It will be seen in the picture that there are quite a number of white

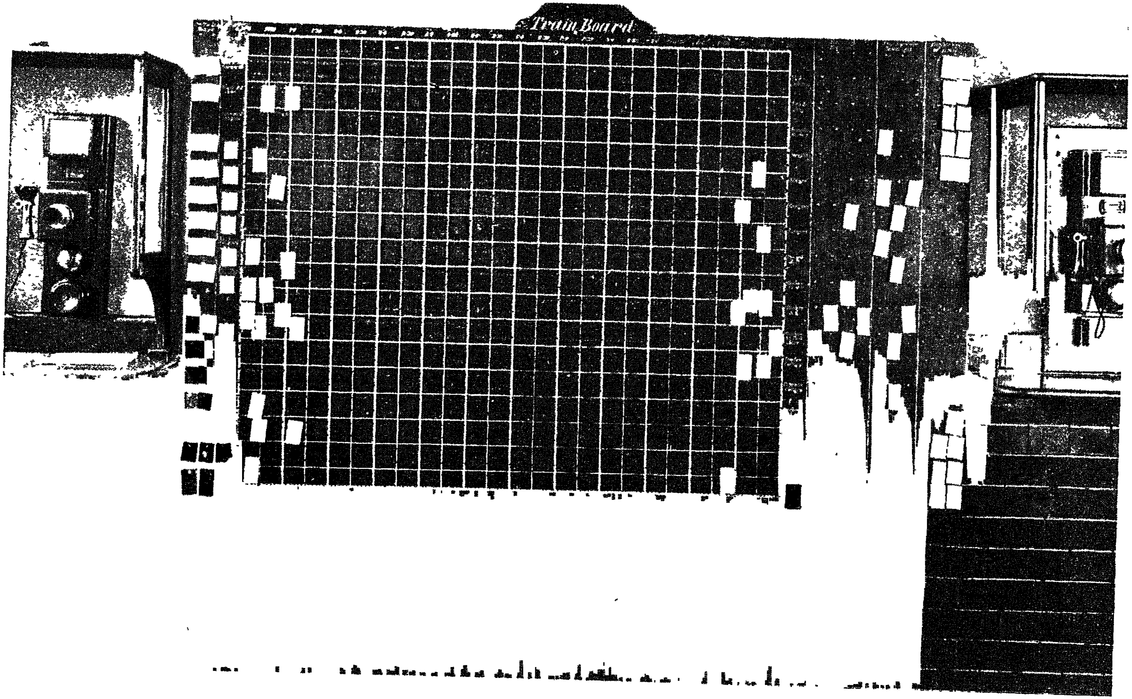

FIG. 24.—PICTURE OF TRAIN BOARD USED IN CONNECTION WITH FREIGHT TRAIN WORKING, MASBORO' DISTRICT CONTROL OFFICE.

cards or tokens in the first, i.e. "out of area" column to the left of the time board, and these cards indicate trains which are expected and have been reported by telephone as on their way but are not actually yet in the control area. As soon as they come within the area they will be pegged on the board.

The time board or control board thus presents in visual form a graphic representation of all freight trains in movement on the main lines of the control area, and it is the business of the controller to see that all trains are worked forward as expeditiously and economically as possible.

The controller on the Midland system, be it remembered, is responsible not only for the efficient working of trains, but also for the economical distribution and working of the locomotives in the district: he therefore wishes to bring on to the control board his shunting engines and the engines working short trips or pilot trips. The latter are practically shunting engines, but are employed in taking wagons for short distances along the main line between siding and siding or shunting yard and other sidings. The recording of these shunting engines is provided for by the columns headed "Shunting Engines" or "Trip Engines Shunting." Tokens representing these engines are hung up in the respective columns or vertical lines in the margin when the engines are busy in the sidings; but if they come out on to the main line to work wagons forward the token corresponding is immediately pegged on the main line or time board. Thus the controller has all of his engines under his eyes, and knows where they are at any moment employed.

The ticket or token is a small card on which are recorded the necessary particulars in regard to the train and its crew. These include:

1. Driver's name.
2. Time driver signed on.
3. Guard's name.
4. Time guard signed on.
5. Number of engine.
6. Train worked.
7. Number of wagons hauled.

The first column to the left of the time board is headed "Traffic to be moved." At periodical intervals during the day (at Masboro' every two hours) a report is obtained at the control office from every station or forwarding point of traffic waiting to be moved, and with this information before him it is the business of the controller to see that any undue accumulation is moved forward.

By this means, then, the controller has before his eye not only the trains which are in motion in his area, but also any accumulation of traffic awaiting transit.

We must ask ourselves next: How is the controller guided in selecting or determining the times at which a train may be sent forward on the main line. All the passenger train times are, of course, fixed in published time-tables, and the great proportion of goods traffic is also forwarded by trains whose times are carefully arranged and printed in the Working Time Table; but as goods and mineral traffic fluctuate so largely day by day, there is always a certain proportion of traffic to be worked by goods trains "as required." It is quite clear that it will not do to send these trains out on the running lines in any haphazard fashion or at any times except such as have been carefully planned so as not to clash with the regular booked trains. To meet this difficulty a diagram or train running graph is prepared for each of the district areas showing in full lines on the graph all the regular trains on the "fast" lines, and in dotted lines all the trains or the "paths" where no trains are running but which represent times at which any additional or special trains could run without delay. Supposing, then, a coal train has to be run unexpectedly from Wath Road past Staveley to the south and the traffic is ready at nine o'clock, as soon as the controller is aware of the requirement he will consult his train times chart and ascertain the next available "path" to Staveley, which is shown to be, let us say, 10.45; he will then order out his engine and book the train forward at the time named, feeling assured that it can get a run through without liability to detention, apart of course from unexpected causes.

The chart of train times and paths in a control district is a somewhat complex diagram, especially in an area of dense traffic; a sample chart or train diagram is reproduced in Appendix VII. It is usually kept on a roller, so that the portion of the chart referring to any particular times of day can be easily and comfortably consulted and read by turning a handle and rotating the roller-chart, so as to bring the particular hour of the day under consideration into the foreground.

With this equipment at hand it becomes the business of the controller to get every train over its course as expeditiously as possible. Of all the regular trains a record is kept daily upon sheets provided for the purpose, the principal particulars being the number of wagons attached or detached at each point of the journey, and the actual times of running as compared with the booked hours, and explanations of any delays have to be inserted. Of such trains as are recorded in detail by the central office at Derby particulars are sent forward from the district controllers.

Now as to the arrangements for relief of trainmen. This is an important function of each district office, and has to be carefully provided for. The organisation is as follows: in the first instance one official in the office is specially told off as trainmen's relief officer, and it is his business to watch the working of every set of men so as to be ready to liberate them promptly when the 8 hours' limit is reached, which of course involves also having a relief set of men to take their places. As soon as each train comes into working in the area and is "under control," a copy of the train token ticket is handed to the relief controller, who keeps a record on a form provided for the purpose, of the men's names and times, arranged in time order, so that as each hour comes along he promptly sees what drivers or guards are coming due for relief, and he arranges accordingly. He has authority on behalf of the section controller to order out engines and men as required; and he is expected to keep in mind that the controller's prime business in the matter of engine power is to combine economy with efficient working.

A heavy responsibility in this matter of engine power rests upon the controller. He is not the direct supervisor of the engine running shed, as the officer in charge—the shed foreman—is a man with co-ordinate authority; but the engines are at the beck and call of the controller. It will be a matter of joint responsibility to determine what degree of margin shall be provided in fixing the number of engines in the shed compared to the average number daily at work. This margin can only be determined by local experience;

it depends not only on the local and daily fluctuations of traffic, but also upon the proportion of engines required to be sent to shops for heavy repairs, or, putting it in another way, on the number of days in the year which the engines may be expected to keep in good working condition for traffic requirements.

So far in our survey of the control office at Masboro' we see that the responsibilities comprise :

1. Watching and supervising goods train working throughout the area.
2. Watching the hours of train crews and arranging relief.
3. Recording the running of the more important trains and transmitting any necessary particulars to Derby.
4. Taking frequent records of traffic on hand at all chief despatch points and arranging to work forward.
5. Economical use of the locomotives in the district.

We must now name the remaining functions which the Masboro' office is called upon to discharge. Every sectional control office acts as a wagon depôt for empty wagon distributing purposes, and once every day full particulars are telephoned from every goods station or forwarding point of : (1) goods wagons on hand under load ; (2) empty goods wagons at station ; (3) goods wagons required for to-morrow's traffic ; (4) surplus or shortage. After comparing surpluses and shortages in the district and removing wagons over at any station to other points in need of stock, the balance of "shorts" or "overs" is telephoned through to Derby, and there the central wagon control makes any necessary adjustments between district and district and keeps the requisite records for future use in regard to the permanent adequacy of stock. Whilst wagons are here spoken of as though they were one uniform unit, all the principal classes of wagons have to be considered, as, for instance, covered or open wagons, cattle or fish wagons, meat-vans, boiler or special capacity wagons, and vehicles for passenger-train working, e.g. milk-vans, motor wagons, horse-boxes, etc.

Under this (L.M. & S.) scheme the district train controller is also a local wagon stock controller. But he is really more than this, for he is the one representative in the local area of the general superintendent at Derby. In most respects he acts as local superintendent of the district. The meaning of this is perhaps best understood when we come to consider the question of the yard working. In every area the supervision of trains may be divided between train running on the main or branch lines, and the work in the marshalling yards or at stations—work which is more or less of a terminal character, including the loading of wagons, the marshalling of wagons, and the make up of trains. To what extent does the control office supervise the work in the goods yard and stations ? We have seen that when the engines are busy *in the yards* the tokens, though taken off the time control diagram, still remain on the margin of the board, so that they are kept under supervision. The yard working is indeed under the supervision and authority of the controller, and this is the plan throughout the Midland section of the L.M. & S. system. Not only the yard working, but also the allocation of the sidings as between different destinations is subject to the sectional controller. The control board with its telephone system becomes the apparatus or instrument by means of which the local superintendent most effectively exercises his function of supervision. It seems an undoubted fact that an increased effectiveness of supervision results from the direct visual method of watching train operating movements which has become possible by the specialised telephone exchange with control board and immediate control, in place of the past system of retrospective surveys taken periodically after the event.

We have described this Masboro' office in some detail because it is a typical control office, and is really the main governing unit in each district through which the principle of control is focussed and exercised; the Derby office, as the centre and heart of the whole system, combines and coordinates the efforts of its twenty-five assistant or district offices.

We may now, with this picture of a local or sectional control office in our minds, return to the Derby central office and endeavour to appreciate its functions and equipment. Trainmen's relief and the local goods train supervision being carried out in the sections, there is no need for train control boards for this purpose at the centre. A few of the more important goods trains are dealt with at Derby, as we shall explain, and the main line passenger trains are here kept under direct control.

On entering the large control room, most conspicuous are the two long tables which run right along the room (see Figs. 30 and 31), which are the control boards for freight and passenger trains respectively working on the main line between London and Carlisle. The freight control board has been out of use for some time, having become unnecessary as the work in the sectional offices has developed under the process of devolution which has been going forward. Reference is made to the passenger train board later. In addition to these two control tables, there are, of course, many telephone instruments, and at either end of the room are cases, wall boards and cabinets for various descriptions of recording in connection with passenger and goods train vehicles respectively. There is also a special control table, with a controller, who keeps supervision over the business of shipping coals.

We may now review the supervision work in this central control office, discussing it under the separate heads of the various functions enumerated in the last chapter dealing with the Manchester (Victoria) control.

Here at Derby, as in the Manchester office, the main aims of central train control are set out in the official instructions as being to obtain the maximum amount of work out of the locomotive power available by:

1. Using the fewest locomotives possible.
2. Incurring the minimum of light mileage.
3. Securing the maximum workable loads.
4. Preventing congestion and delay by regulating converging streams of traffic.

At the central office of a large system covering some 2,169 miles* of railway track, the work will necessarily be different in most particulars from the work of a sectional office: diagrams, statistics and summaries will have to be much more freely used, and experts in the various sections of work will need to have each his own office and clerical assistance. A district or sectional controller is train supervisor, carriage controller, wagon controller, locomotive power manipulator all in one; at the head office each of these several functions will require to have its separate responsible head, and as it is of much importance that all these heads should be in close juxtaposition and conveniently situated for ready and constant consultation, the arrangement of office room is important. A suite of rooms arranged round the central control room, with its boards and telephones, is the arrangement which lends itself most effectively to good organisation and prompt action, and in this respect the L.M. & S. Railway control office at Derby is very advantageously situated.

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* This was the old Midland figure. The L.M. & S. Railway, for which Derby now acts as Central Control Office, extends over 7,214 miles.

An inspection of the diagram or ground plan of the complete control offices at Derby on page 156 will show that whilst the immediate control arrangements are carried out in the large office with its control boards and telephones already described, close at hand, indeed in the same large room, are the carriage and wagon distributors (or controllers), and separated by only a short corridor the offices of superintendent of freight trains, assistant superintendent of freight trains, superintendent of passenger services; only just beyond, and close at hand for reference when necessary, are the departmental offices dealing with excursion arrangements, freight train correspondence, engine workings, passenger guards workings, statistics, diagrams, etc. Constant passing of clerks backwards and forwards between the various offices and the control office is a marked feature: indeed, the control office and its equipment has become *par excellence* the one main mechanism through which the various offices in any way connected with train working (goods or passenger) do their work and get into practical touch with the current facts of train movement.

Dealing now with the various functions of train control:

1. As regards the *supervision of goods train working*, this is carried out in the sections, and the Derby office is relieved of this work, excepting as regards more important trains.

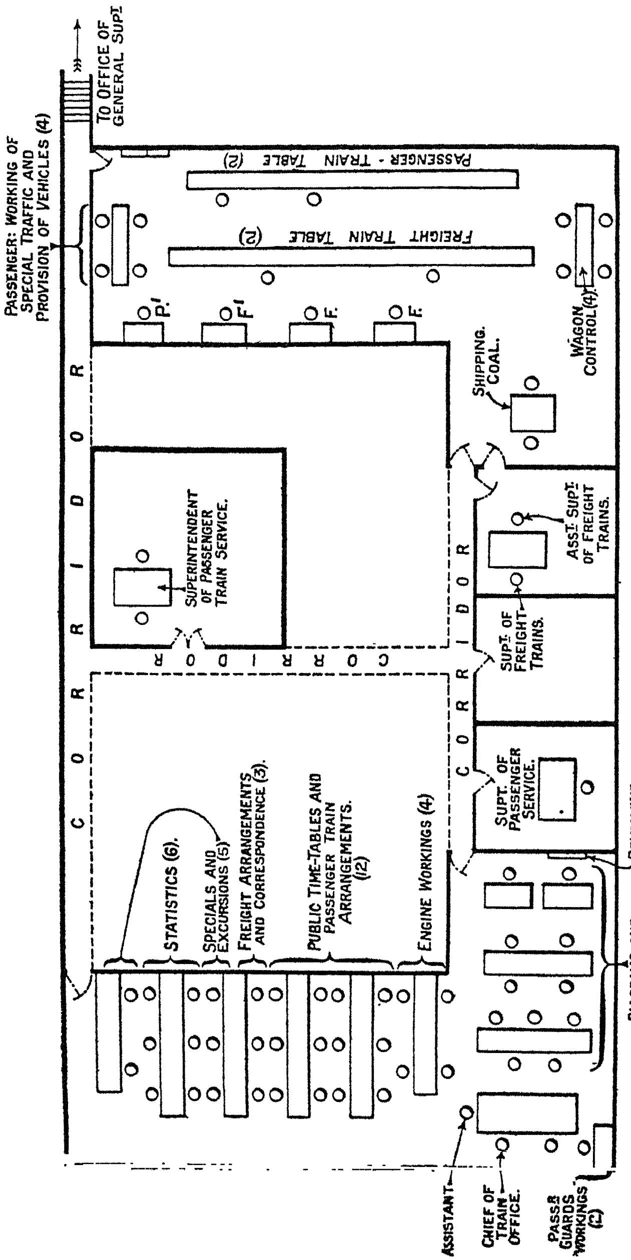
TO OFFICE OF GENERAL SUPT.
PASSENGER: WORKING OF SPECIAL TRAFFIC AND PROVISION OF VEHICLES (4)
PASSENGER - TRAIN TABLE (2)
FREIGHT TRAIN TABLE (2)
P.¹
F¹
F.
F.
CORRIDOR
SHIPPING. COAL.
WAGON CONTROL (4)
SUPERINTENDENT OF PASSENGER TRAIN SERVICE.
CORRIDOR
ASST. SUPT. OF FREIGHT TRAINS.
CORRIDOR
SUPT. OF FREIGHT TRAINS.
CORRIDOR
SUPT. OF PASSENGER SERVICE.
REVOLVING DIAGRAM.
DIAGRAMS AND TIME TABLES (11).
STATISTICS (6).
SPECIALS AND EXCURSIONS (5)
FREIGHT ARRANGEMENTS AND CORRESPONDENCE (3).
PUBLIC TIME-TABLES AND PASSENGER TRAIN ARRANGEMENTS. (12)
ENGINE WORKINGS (4)
ASSISTANT
CHIEF OF TRAIN OFFICE.
PASS.R GUARDS WORKINGS (2)

FIG. 25.—GENERAL ARRANGEMENT OF CENTRAL TRAIN AND CONTROL OFFICES, DERBY.

It is considered desirable to keep daily records of:

1. Important freight trains to London.
2. Important freight trains from London.
3. Important provincial freight trains (up).
4. Important provincial freight trains (down).

These are retained in the Derby office.

As regards each of the forms used for these trains, a record is provided for the actual time of starting, time of arrival at various stations *en route* and at destination, with explanation of any serious delays or abnormal working. All this is recorded directly by telephone as the train progresses on its daily journey.

A special statement of mineral train running is also kept, on account of the importance of the main line coal traffic between Nottinghamshire and Derbyshire and London.

2. *Relief of trainmen* and provision against long or unreasonable hours. This work is entirely attended to in the sectional offices.

3. *Control of Goods Wagon Stock.*—The daily distribution and allocation of goods wagons is an important function of the central office. The question is more fully dealt with under a separate heading "Rolling Stock Control" (see page 161).

4. *Supervision of Passenger Train Working.*—The main line trains are all dealt with in this office under special arrangements for control, with a special control board. These arrangements are all fully set out under the heading "Control of Passenger Trains" (see page 165), under which heading the question of recording of the running of passenger trains is also dealt with.

5. *Control of Passenger Carriages and Stock.*—This control is also centred in the Derby trains control office. The methods employed are all described under the heading "Rolling Stock Control" (see page 163).

6. *Allocation and Control of Guards' Vans.*—The stock of guards' vans or "brakes" is allocated to the different districts, each of which is expected to keep control of its own vans. But in order to keep a check on the total stock, a weekly census is taken on Sundays at every centre, and a return sent in to the control office at Derby every Sunday from each centre. The return is in the following form:

CENSUS OF GOODS BRAKES.

NUMBERS OF GOODS BRAKES ON HAND.

At..Station or Depot.

Noon, Sunday..192....

Ordinary Brakes.*			Fitted Brakes.*			Brakes under Repair.
10 ton.	15 ton.	20 ton.	10 ton.	15 ton.	20 ton.	
....	....	....	....	....	....	....
....	....	....	....	....	....	....
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....	....	....	....	....	....	....
....	....	....	....	....	....	....
Total on Hand.						
Number Allotted.						

* Excluding brakes under repair.

....*Signature.*

Fig. 26.—Census of Goods Brakes Return Sent in Weekly.

7. *Allocation and Distribution of Locomotive Power.*—The amount of control exercised over the distribution and economical use of the locomotive power through the agency of the central control office must depend to no small extent upon the general organisation of the railway company in regard to the relation between locomotive and superintendents' departments. In earlier days the control of locomotives has in practice rested entirely with the locomotive superintendent. Under this older method of organisation, when the central train control method was started it involved the placing of a locomotive department representative in the control office to work jointly with the traffic representative so that they could in consultation arrange the provision of engines as required, or book off the enginemen when they had worked long enough shifts. But the experience which is resulting from central control is bringing the locomotive staff into ever closer contact with the traffic representatives responsible for train working, until the position has been reached, and the view is now generally taken that the engines which haul the trains and the traffic arrangements as to train working and despatch *should be under one and the same authority.* On the Midland section of the L.M. & S. Railway, therefore, the whole of the locomotives when in commission for traffic purposes are entirely under the supervision and control of the general superintendent. The exact organisation will be best understood by the perusal of the diagram of organisation shown on the next page.

This plan of organisation, which seems to be coming more and more into vogue in Great Britain—it has for long been the method adopted in America—throws a much greater degree of responsibility upon the head of the operating department, the general superintendent, for it requires that this officer should either himself be a skilled locomotive engineer, or else should have an engineering assistant competent to supervise the necessary repairs of the locomotive stock and to form a competent opinion as to the degree of repairs to be undertaken for any disabled locomotive, and also as to the best description of engine for any particular character of work. It also places under direct supervision of the general superintendent the complete army of drivers, firemen, and

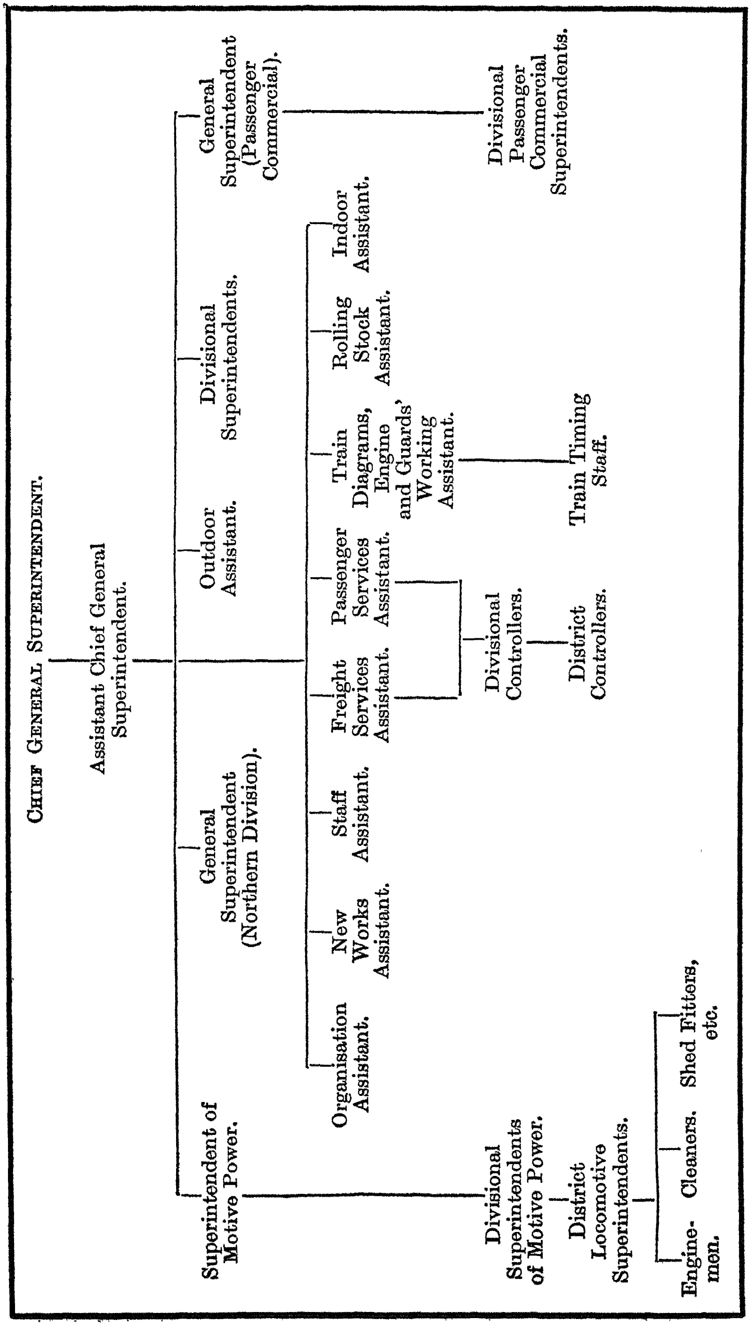
CHIEF GENERAL SUPERINTENDENT.
Assistant Chief General Superintendent.
Superintendent of Motive Power.
General Superintendent (Northern Division).
Outdoor Assistant.
Divisional Superintendents.
General Superintendent (Passenger Commercial).
Organisation Assistant.
New Works Assistant.
Staff Assistant.
Freight Services Assistant.
Passenger Services Assistant.
Train Diagrams, Engine and Guards' Working Assistant.
Rolling Stock Assistant.
Indoor Assistant.
Divisional Passenger Commercial Superintendents.
Divisional Controllers.
District Controllers.
Train Timing Staff.
Divisional Superintendents of Motive Power.
District Locomotive Superintendents.
Engine-men.
Cleaners.
Shed Fitters, etc.

FIG. 27.—SUPERINTENDENT'S ORGANISATION: PRESENT L.M. & S. ORGANISATION.

running-shed staff throughout the line, and relieves the locomotive superintendent of this function. This method of locomotive power control keeps track of engine distribution in the first instance by a weekly census showing where all engines are stationed. At nine o'clock every Monday morning every locomotive depôt sends to the Derby control office a complete return showing the position of the engine stock at that time, both passenger and goods, with information as to the condition of each and the percentage of the total stock in the shops for repair.

The particulars of each locomotive as received on the above forms are entered upon cards—a card for each engine—and these cards are kept for reference in a small cabinet which is divided into six sections: Carlisle–York, Sheffield–Manchester, Buxton–Derby, Burton–Bristol, Toton-Wigston, and Kettering–London, the classes of engines being all kept distinct. The record form employed is set out on page 196.

All this information is, of course, essential in order that the operating department staff attached to the control office for the purpose may effectively and economically arrange the engine workings for the daily traffic requirements.

8. *Marshalling Yard Working and Supervision.*—As has already been explained, the marshalling yard supervision is vested in the sectional controllers, and all that is necessary for the central office in connection with these yards is to compile general statistics such as the number of wagons entering and leaving each of the large yards. These figures are transmitted by 'phone over the control wires and tabulated at Derby. The detail work of each marshalling yard is, of course, supervised from the sectional or district offices.

ROLLING STOCK CONTROL: WAGONS

The Midland system of wagon control is centered under the general superintendent at Derby ; and instead of being worked as a separate department, as with some companies, it is combined with the train control office, and the control telephones are used for transmitting the information required by the wagon controller. This information in the main consists of two censuses, one at one o'clock in the morning and a second at four in the afternoon. At 8 a.m. every centre telephones to Derby the number of empty wagons it has on hand and the number of wagons required for the day's loading. These particulars have to be obtained for every description of wagon, and the surpluses and shortages in each local section have to be balanced against each other and the necessary arrangements for transfer of surplus or spare wagons to the points where they are wanted for loading purposes are then made by the train control staff. The advantage of having the arrangements for transfer from point to point and the allocation of wagons between different districts in one central office is obvious.

The chief wagon controller and his assistant occupy desks at the side of the general control, and determine the daily arrangements for allocation of wagons after consideration of the information collected from the local depôts, and they keep their records of special descriptions of the goods wagons on cards in cabinets at one end of the room. Illustrations of these card cabinets are given in Figs. 28 and 29. They represent a general view of the freight rolling stock card cabinet and a more detailed view of one cabinet with the indicators on each card in position. These indicators are of an interesting nature. A small revolving 4-colour disc is attached behind the upper right-hand corner of every card, the corner being slotted to show one colour of the indicator disc ; and by this colour scheme an indication is given whether the wagon is on hand empty and spare (white), on hand empty but required (red), on hand loaded (blue), expected to arrive empty (green). Thus a glance at the card only is required to see whether the wagon is spare and available or whether it is already bespoken.

A list of the various types of rolling stock (passenger and goods) owned by the old Midland Railway and two of the return forms used for collecting the daily information required by the wagon controller to enable him to make a satisfactory distribution of stock are set out in Appendix IX. The list shows the great variety of the types of wagon which have to be dealt with.

Eight o'clock in the morning is selected for the main adjustment of wagons, as between the various districts, so that the best utilisation of the available stock may be made

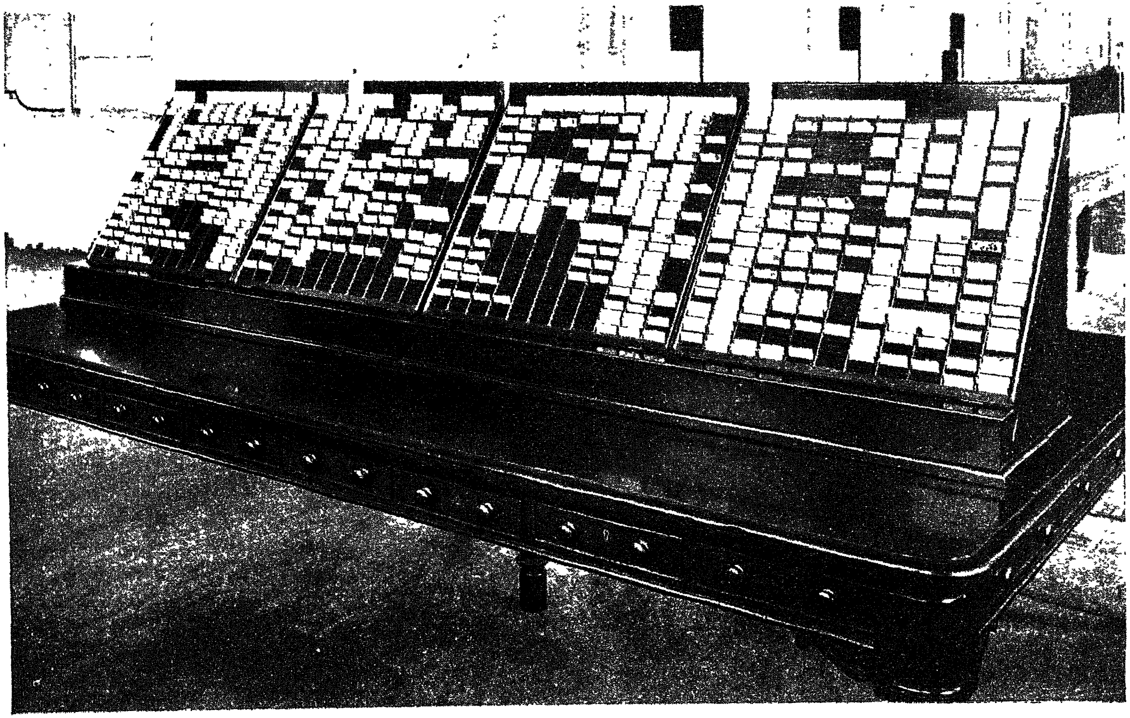

Fig. 28.—General View of Freight Train Rolling Stock Cabinet, Central Control Office, Derby.

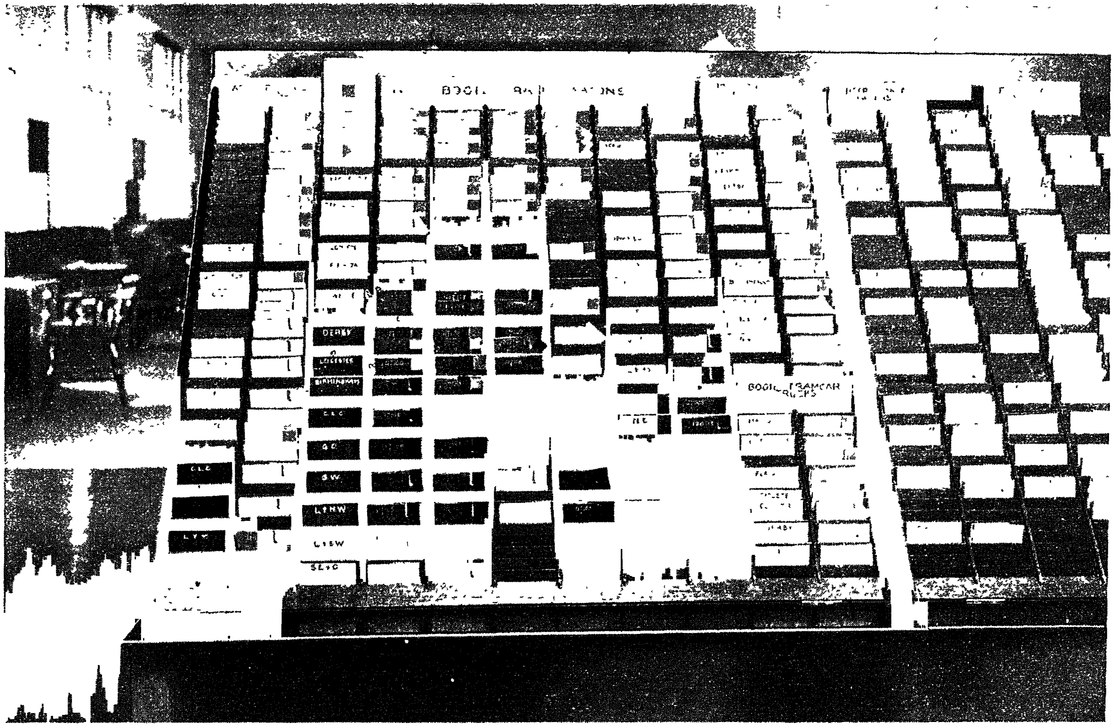

FIG. 29.—SECTION OF CABINET WITH FREIGHT TRAIN ROLLING STOCK INDICATORS IN POSITION, CENTRAL CONTROL OFFICE, DERBY.

for the day's requirements. As twenty-five districts have to send in similar returns, they are arranged in accordance with a precise time-table between 8 and 8.30, so that they follow one another in regular sequence instead of all coming at one and the same time precisely.

As regards specially constructed vehicles, the day by day working is recorded by means of card indexes. The principal types of these wagons are boiler wagons, bogie rail wagons, armour plate wagons, implement wagons, tank wagons, motor-car vans, refrigerator vans, timber wagons, sleeper wagons. The work of each of these wagons is recorded on a card, and the cards are kept in cabinets like the one set out in the illustration, Fig. 28. Every morning after receipt of the census figures, the demands for each class of special wagon are set out against the spare or unloaded wagons as returned from each centre, and the day's work of each is recorded on its appropriate card, and from the card indications the supplies are adjusted. Further particulars of this method of dealing with specially constructed wagons appears in Chapter XVI. The total number of goods wagons of all kinds owned by the old Midland Railway was about 115,000. The number belonging to the L.M. & S. Railway Company is 308,122.

ROLLING STOCK CONTROL: PASSENGER

The method of controlling and distributing passenger stock is in its main features the same as that for the distribution of goods wagons. Indeed as regards all vehicles other than passenger carriages, i.e. horse-boxes, fish wagons, motor vans, carriage trucks, the method is just the same as in the case of goods wagon stock. A card cabinet is maintained for each class of vehicle, and the cards relating to each type are promptly filled up as the particulars of each day's working are received.

As regards passenger carriages, a record of all spare vehicles is kept in the control office and adjusted by daily census returns as to the present location of spare stock; and whenever a request comes for additional carriages a selection of the right type is made, and the vehicle immediately transferred to the point where it is required for working. It is clearly understood that no extra vehicle is to be placed on any train excepting after arrangement with the Derby control office; and the convergence of this working on the one central point secures that the utmost economy is assured in the distribution of vehicles. It may at first sound unnecessarily cumbersome and as partaking unduly of "red tape" methods to require that, say, the York or St. Pancras station master in times of pressure from an unexpected crowd presenting itself for a particular train to have to consult Derby control office before it can add a vehicle to a train; but it is to be remembered that with an efficient telephone system it is as easy for York station master to consult Derby with a request for an extra carriage as it is to send out a shunter to the carriage sidings to find a spare carriage. In any event, however, experience shows that the method is working well and efficiently.

The system of arranging the daily passenger train "extras" deserves some notice. The "extras" are the additional vehicles beyond the normal make-up which are day by day added to the train. It is understood that every passenger train has a regular standard make-up. The "formation" of each train is fixed in advance and carefully recorded in printed instructions, and no alteration of the standard formation is allowed except under the authority of the control office. But constant additions have to be made. There is, for instance, the weekly recurrence of market days when local or branch trains have to be strengthened; there are pleasure parties travelling by saloon, as well as the addition of carriage trucks, horse-boxes, scenery vans or reserved carriages for theatrical parties, and many other circumstances differing from the normal. These special vehicle requirements are dealt with by keeping in display, fixed upon the wall at the passenger department end of the room, two "extras" boards, one for to-day and one for to-morrow, on which are hung the card tokens for the two days representing the extra vehicles, with an indication of the trains to which they are to be attached. In the first instance, whenever a requisition is received in the superintendent's or passenger department office for an extra saloon or other vehicle, as soon as it is agreed upon the particulars are transmitted to the passenger control office, and they are at once recorded on a card token:

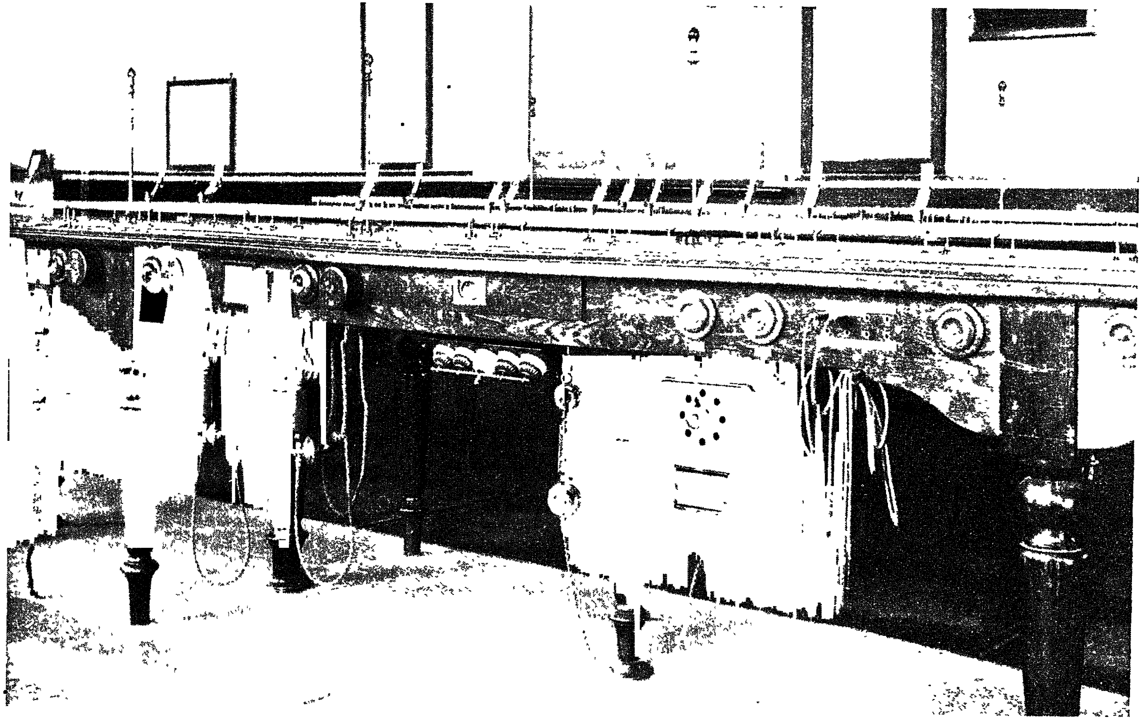

FIG. 30.—GENERAL VIEW OF PASSENGER TRAIN CONTROL TABLE, SHOWING TELEPHONIC EQUIPMENT AND ELECTRIC LIGHT CALLING INDICATIONS, CENTRAL CONTROL OFFICE.

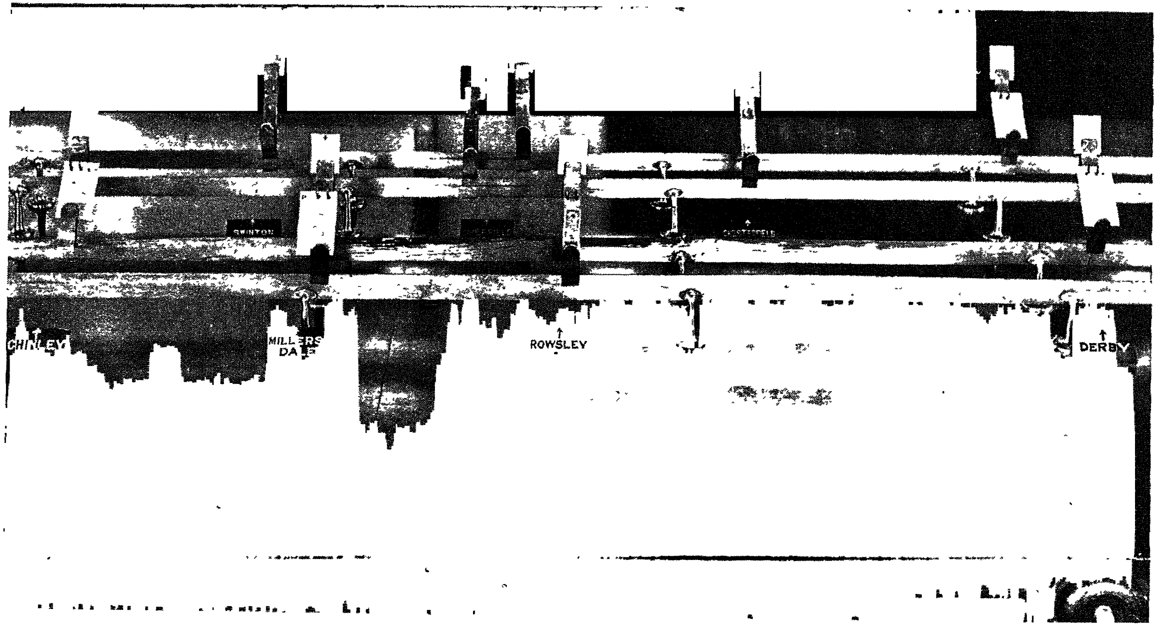

FIG. 31.—VIEW OF PASSENGER TRAIN CONTROL TABLE, SHOWING MAIN LINE ON SCALE OF 1 INCH TO 1 MILE, "STATIONS" AND "TRAINS" CENTRAL CONTROL OFFICE.

these cards being placed in an appropriate cabinet in datal order, and then every night at midnight a boy is told off to take the next day's cards from the cabinet and place them on the board, taking down the cards from the day just completed. Before the completed day's cards are finally filed arrangements have to be made by passenger control to get the vehicles when unloaded back to their proper depôt or abiding place. The function of these passenger trains "extras" board is to keep displayed the extra vehicle requirements, so that by a glance the day's requirements in the way of extra vehicles to be attached to any particular train may promptly be seen and arranged for.

CONTROL OF PASSENGER TRAINS

This is one of the most important and at the same time most interesting phases of the work of the Derby control office. Reference was made at the outset of this chapter to the two control tables which form, perhaps, the most conspicuous feature in the control room. On the table are fixed two pairs of rails representing the main line of the Midland Railway from London to Carlisle, Derby to Manchester, and Derby to Bristol; all the stations, junctions and control points are also indicated, and direct telephonic communication is provided to each of these points. Every passenger train in motion on the main line is represented by a card clipped on to the rail and moved along from station to station as the train progresses on its journey in accordance with current telephonic messages received. On entry into the office at any time one may walk up to the passenger control board and see just what passenger trains are moving along the line, and where they are located at any moment. The scale of the track is one inch to one mile. A representation of this board is shown in the two pictures (Figs. 30 and 31). The first shows very clearly the telephone attachments, and on the second will be seen a number of card tokens or tallies, each representing a passenger train. An examination of one of these passenger train cards shows that it contains information as to "Registered No." of the train, the starting and finishing point, the place, if any, en *route* at which engines are changed. The "Registered No." of the train gives its normal make up, but if there are special vehicles attached these "extras" will be indicated by a supplementary card clipped in with the train card, and similarly should there be a second engine employed that also would be indicated on the clip, so that the tickets upon the board give a complete representation of the actual composition of the train.

Passenger train control was introduced on the Midland system on January 1, 1917, when 520 expresses were brought under control, these including all the principal trains on the main line. As each of there trains leaves its departure station a telegraphic advice is given to the control office of the time of departure, class of engine and condition of loading. Most of the information is transmitted in code form, and a copy of the form on which it is recorded is set out in Fig. 32, page 167.

A similar return is made up of trains *arriving* at terminal stations, and a copy of this return is also given in Fig. 33, page 168.

As each train arrives at its destination, the report simply gives the number of the train and its actual arrival time. By means of these telegraphic particulars the control office is able to keep continuous watch over the train as it proceeds on its journey.

A point of importance in connection with this passenger train control is the recording of the loading of each train. The weight of every vehicle is inserted in the record of each train, and as the train control and the passenger vehicle control is in the one office, the weight of any vehicle is easily obtainable from the rolling stock controller's records. In Appendix VI is given a sample of the record sheet that is kept of each passenger train under control for this purpose, and from this it will be seen how the weights of the train are recorded under three columns: (1) The tonnage of the vehicle; (2) the engine tonnage capacity; (3) and the margin between the two. These figures are on the basis of the normal formation and with this record before him the controller knows whether it will be safe to add further vehicles if required, and to what extent, without overloading the locomotive, and so jeopardising punctual running. Incidentally, too, this method of tonnage recording

LONDON, MIDLAND AND SCOTTISH RAILWAY.

ACTUAL DEPARTURE OF TRAINS FROM..............................STATION.

Week ending..............................192...

TRAIN.		MINUTES LATE.						TRAIN.		MINUTES LATE.					
Time.	To	Mon.	Tues.	Wed.	Thur.	Fri.	Sat.	Time.	To	Mon.	Tues.	Wed.	Thur.	Fri.	Sat.

"—" Denotes right time.
"NR" Denotes "Not run."

..............................*Station Master.*

FIG. 32.—WEEKLY RETURN OF DEPARTING PASSENGER TRAINS RENDERED BY TERMINAL STATIONS. REVISED FORM AS IN USE AT PRESENT.

LONDON, MIDLAND AND SCOTTISH RAILWAY.

ACTUAL ARRIVAL OF TRAINS AT..............................STATION.

Week ending..............................192....

TRAIN.			MINUTES LATE.						TRAIN.			MINUTES LATE.					
Time.	From	Due. Arr.	Mon.	Tues.	Wed.	Thur.	Fri.	Sat.	Time.	From	Due. Arr.	Mon.	Tues.	Wed.	Thur.	Fri.	Sat.

"—" Denotes right time.
"NR" Denotes "Not run."

Number of Trains Arriving.						Weekly Total Number of Trains Arriving.
Punctual.	1 to 5 Minutes Late.	6 to 10 Minutes Late.	11 to 20 Minutes Late.	21 to 30 Minutes Late.	Over 30 Minutes Late.	

..............................*Station Master.*

FIG. 33.—WEEKLY RETURN OF ARRIVING PASSENGER TRAINS RENDERED BY TERMINAL STATIONS. REVISED FORM AS IN USE AT PRESENT.

at once suggests an alternative to that of ascertaining the tonnage weights of the trains by means of guards' journals and the guards' calculations—at least so far as passenger trains are concerned. This is a point worthy of note, for it is sometimes suggested as a formidable difficulty in the way of recording the tonnages of trains that it is impracticable for the guards to keep accurate records.

The running records of passenger trains controlled are carried out by record clerks in the control office concurrently with the receipt of the information as to how the trains are running. For each train controlled particulars of the running are set out in comprehensive form which embodies "minutes late at the principal stations *en route*," "Class and number of engine," and "tonnage weight of train." The trains are all grouped on five large forms, one including all up trains between London and Carlisle, and another all down trains; one each for up and down trains north of Leeds, and one for both up and down for Leeds and Bristol. This method is adopted for all "controlled" passenger trains, which includes all the principal expresses: in regard to other trains, a two-monthly statement of running times showing total minutes delayed and minutes late in arriving at stations is sent and recorded for each day separately, so that the passenger train controller can have before him a survey of the running of all trains on the line. The return also shows the extra vehicles conveyed by each train during the period.

A supplementary return to those already mentioned is sent in at the end of each week by all stations at which trains either start or terminate, showing the number of minutes, if any, the train was late at start or at destination. These returns are scrutinised by the passenger controller, who makes special inquiry as to detentions if the circumstances appear to call for such action.

There are various other developments of considerable interest which have sprung up as more or less subsidiary to the main functions of control, some of which, however, deserve mention. Some of these are more or less special to the L.M. & S. (Midland) system circumstances, but others might have similar application at any central train control office.

The working of perishable traffic trains, e.g. seasonal fish traffic conveyed by fast special trains or dead-meat trains from Carlisle to London, are all specially watched throughout their journey and " controlled " throughout. Many of these are difficult to regulate as regards locomotive power and reception accommodation because of the great variation in the number of wagons required owing to traffic fluctuations. And it is here that central control comes in as of special advantage, because there exist in one office all the resources for making prompt arrangements for obtaining or altering the engine power required, securing and allocating the exact number of wagons necessary, and advising forward the amount of traffic so that reception and terminal services and accommodation may be arranged.

What is known as " piloting " is also supervised from the control office, and here much economy has been effected. By piloting is meant the system of keeping a spare engine standing in readiness—" standing pilot " it is technically called—at the principal stations along the main line to be at call in case of any of the regular engines finding itself overloaded and immediately needing assistance. As the control office knows exactly the loading of each train (and indeed is often able to limit the load to prevent undue strain upon the engine), it is found that much economy in the arrangement of these " standing pilots " has been effected, and indeed most of the engines which were relied on to " stand pilot " under the old system are now no longer necessary.

Then there is the question of station platform accommodation and " drawing up " of unusually long trains. The control office has done not a little to reduce the troubles arising from this cause. The office has full particulars of the length of all station platforms, and when a train is of such length as to necessitate part of it standing beyond the platform end at stopping stations *en route*, the precise facts are calculated in advance, and at all stations in the rear passengers for the particular stations where the train is known to be too long for the platform are warned to avoid the rear carriages or a certain number at the front as the case may be, and a great deal of the drawing up a second time is by this means obviated and much trial of human patience as well as time avoided.

Both as regards coal for shipment and coal for London it has been found advantageous to institute special arrangements in the Derby office for "control" with manifestly beneficial effects all round. As regards coal for shipment, the railway officer knows all too well what a universal tendency there is on the part of forwarding collieries to send forward coal, often in train loads for a shipping order—say at Bristol or Liverpool—not uncommonly before the ship is ready to receive it, sometimes even days before the ship is in port. Such trains or wagons of coal are a considerable encumbrance on the running lines, and it usually happens that they come forward in greatest frequency when from other causes there is a glut of traffic tending to a congestion of train working. A control office at once furnishes the machinery for regulating this traffic. The controller will obtain information from the receiving port, the destination of the traffic, exactly what ships are at the berths waiting for traffic, and how many wagons are required, with specifications of each, and can then work the traffic forward under control from colliery to destination at the times when clear and unobstructed pathways on the line exist. He need not accept from the colliery the train loads until he knows the ship is in readiness to receive its cargo, and so a solution is provided for a problem which has always been attended with difficulty. Collieries are always anxious to get their sidings clear of traffic, and would much rather have their loaded traffic standing upon railway ground than upon their own. Traffic of this kind, perhaps more than any other, needs to be controlled.* To deal with this important traffic effectively, there is in the control office a sectional desk for the shipping coal controller, who has a geographical board indicating the coal-producing areas in the Midland area, and such railway storage sidings as exist for this class of traffic, and with the information as to traffic at each colliery ready to be forwarded under shipping orders, and information from the shipping end as to the ships ready to receive the traffic, and the geographical board to guide him, the controller exercises his function of restraining

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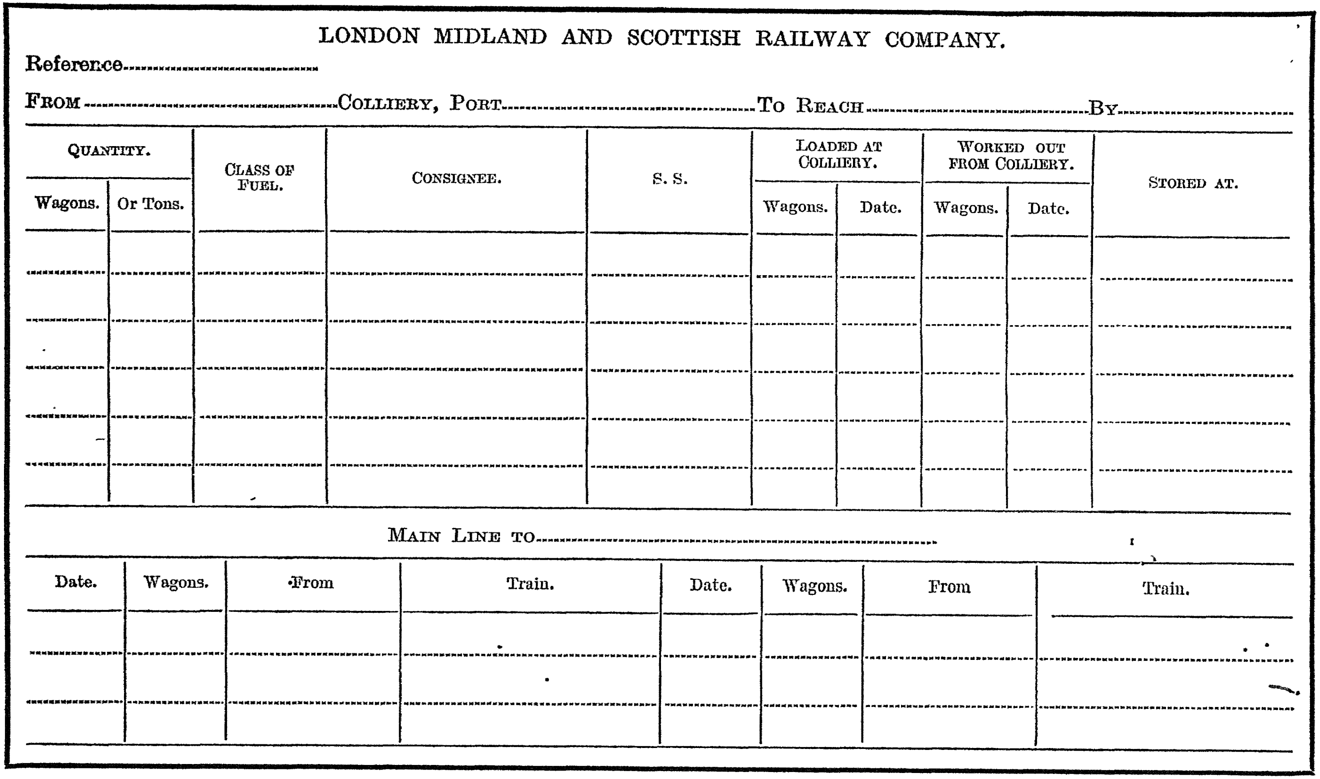
* This factor will be fully appreciated after reading the circumstances described in some detail about the Hull coal shipment traffic (Chapter X, pp. 115 *et seq.*).



LONDON MIDLAND AND SCOTTISH RAILWAY COMPANY.

Reference................................

FROM ....COLLIERY, PORT..............................TO REACH..............................BY..............................

QUANTITY.		CLASS OF FUEL.	CONSIGNEE.	S. S.	LOADED AT COLLIERY.		WORKED OUT FROM COLLIERY.		STORED AT.
Wagons.	Or Tons.				Wagons.	Date.	Wagons.	Date.	

MAIN LINE TO..............................

Date.	Wagons.	From	Train.	Date.	Wagons.	From	Train.

FIG. 34.—CARD USED IN CENTRAL CONTROL OFFICE (L.M. & S.R.) IN REGULATION OF SHIPPING COAL TRAFFIC.

the traffic or working it forward as the case may require. One of the daily returns used for this purpose of controlling coal for shipment is set out in Fig. 34, page 172, namely, a return of coal on hand at each particular colliery, with a statement of the ship it is destined for at the port, and the time by which it is required. A second return is received each morning of coal for shipment on hand at the "resting sidings" on the railway *en route* to the port.

A similar arrangement of reports and daily returns is adopted in connection with the important stream of coal traffic always flowing from the Nottinghamshire and Derbyshire collieries in the Midland area to London. Returns from the collieries and from resting sidings *en route* are sent in daily, and returns from London receiving depôts on parallel lines to those sent in by the port stations are received by the control office so that the controller may regulate the flow of traffic to London. By this means full particulars of every wagon (with its contents) which is on the way from collieries to London for each merchant are readily available for the controller.

The concentration of all this information in the control office is of value, as it enables any enquiry from a London merchant as to where any coal which he has on order is to be found to. be answered without delay, that is, if the coal has already been despatched from the colliery.

It is in connection with any special working of this kind that the arrangements under a system of central telephone control become of especial and often quite unexpected advantage, and make very definitely for increased efficiency.

We have ventured to give a very considerable account in detail of the many supervisory activities of the Derby control on the L.M. & S. system, because it is probably the most extensive application of a central telephone train control that has as yet been established. Commenced though it was in the first instance for the more efficient control of goods and mineral trains in one district, its direct influence has extended far beyond these, and one of the most striking testimonies to its effectiveness is seen in the statistical table given below relating to the running of passenger trains in recent years. It is simply a tabulation for a series of recent years of what is known as the annual punctuality return. This return gives in separate columns the number of trains not more than 5 minutes late on arrival at their destination station and the number which *are* more than 5 minutes late, with the percentage of the former out of the total number. The trains are also divided as between local and express. The improvement recorded since 1917—the year when passenger train "control" started on the Midland—is indeed extraordinary. How much of this improvement is to be credited to the new control arrangements may be a matter for speculation; but the fact is that a tremendous improvement has taken place which must be due to better management and supervision, and it is a fair conclusion that the new instrument of supervision which the train control office provides has played no unimportant part in the alterations.

London, Midland & Scottish Railway Company, "Midland Section."

Year.	Total Number of Trains.	Number of Trains punctual or not more than 5 Minutes late.		Number of Trains over 5 Minutes late.		Percentage punctual or not more than 5 Minutes late.	
		Express.	Local.	Express.	Local.	Express.	Local.
1916	715,895	9,791	545,097	10,650	150,357	47·9	78·4
1917	407,868	11,728	337,986	3,660	54,494	77·0	86·0
1918	412,781	21,013	358,299	3,151	30,318	87·0	92·0
1919	441,365	25,819	371,567	4,148	39,831	86·0	90·0
1920	527,021	32,722	443,664	4,849	45,786	87·0	91·0
1921	514,934	32,882	436,658	6,095	39,299	84·0	92·0
1922	681,004	40,874	581,301	6,982	51,847	86·0	92·0
1923	842,100	54,571	685,310	10,878	91,341	83·0	88·0
1924	872,853	52,933	672,281	15,270	132,369	78·0	84·0

Note.—During 1917 ordinary passenger train mileage was reduced owing to war conditions by about 37 per cent. less than the service worked in 1916.

Fig. 35.—Summary of Passenger Train Working.

The old Midland system is now only a part of the greater whole, the L.M. & S. Railway: it is known as the Midland Section. The old L. & N.W. Railway is now the L.M. & S. Railway, Western Section; it also has its train control system and machinery. In many respects the methods employed are the same, and now that they come under one management we may expect to see all that is

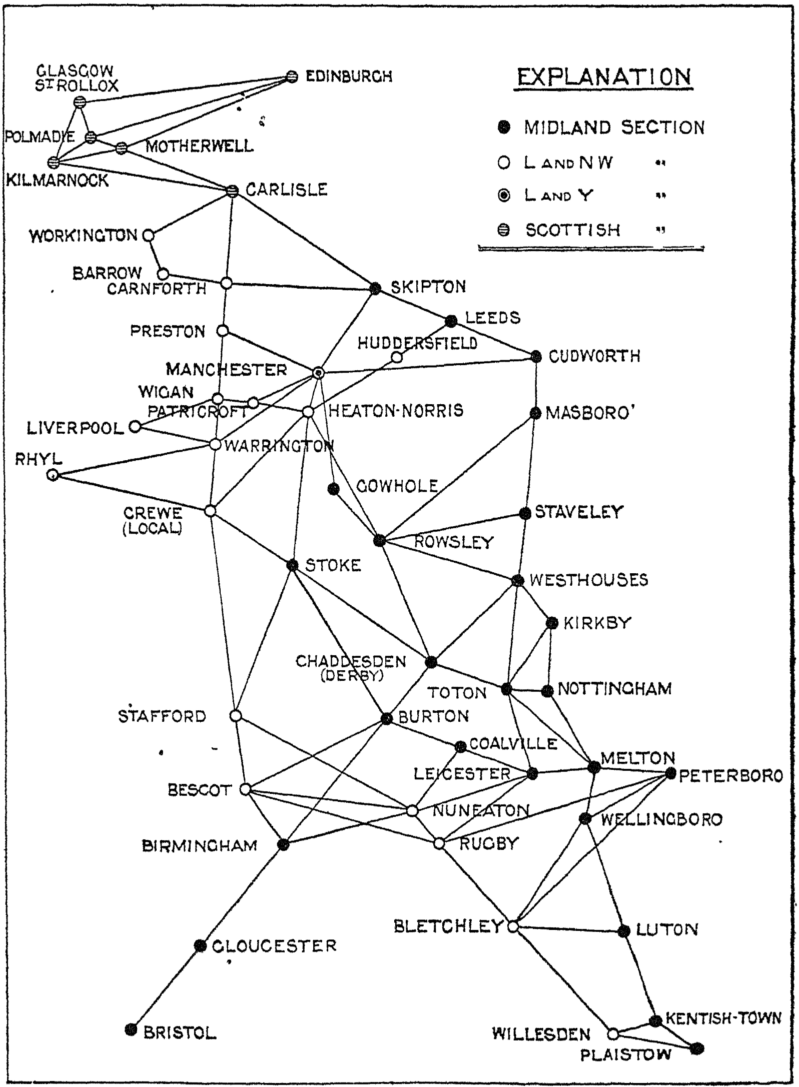


FIG. 36.—L.M. & S. INTER-DISTRICT CONTROL TELEPHONIC COMMUNICATION.

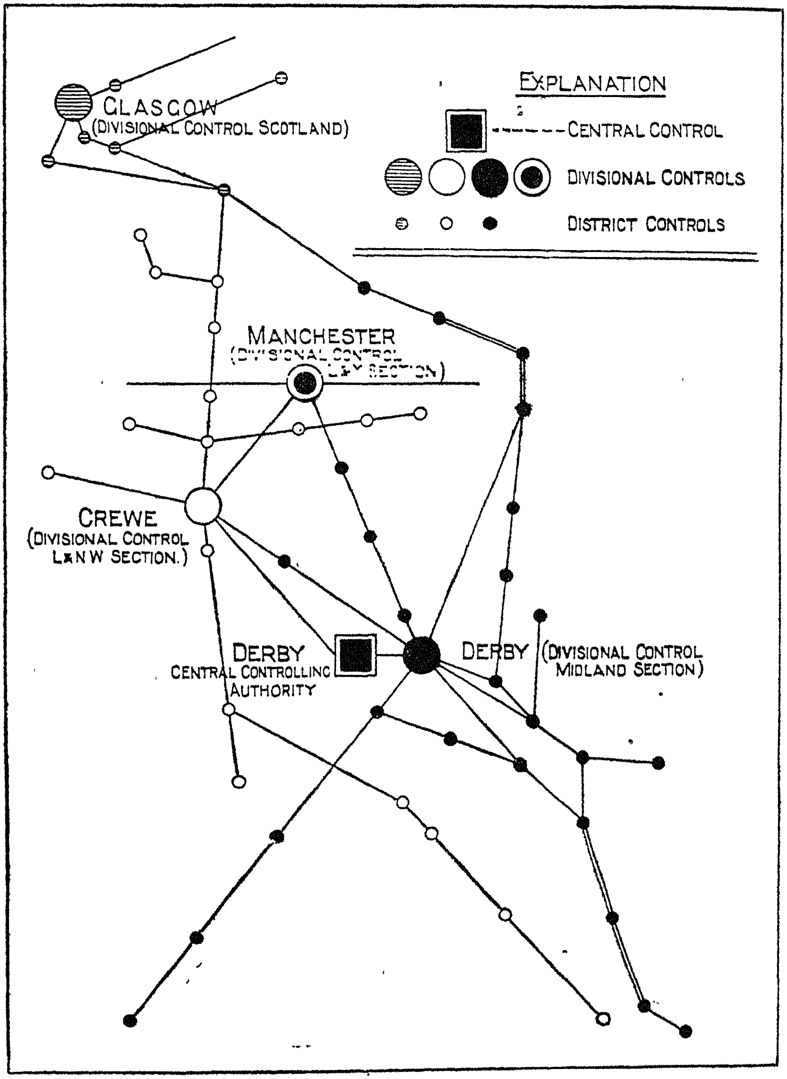


FIG. 37.—L.M. & S. CONTROL TRUNK TELEPHONE CIRCUITS.

best in either system remain as the process of unification goes on.

The old L. & Y. system, with its Manchester (Victoria) central control office, described in the preceding chapter, comes also under the same extended and enlarged management. So also does the "control" system which existed on the old Caledonian Railway: it constitutes a Scottish section of the L.M. & S. Railway control.

The four sections are interconnected by a complete system of telephones, and the diagram on page 175 (Fig. 36) shows the lines of this system of telephone intercommunication, whilst the diagram in Fig. 37 shows the telephone trunk circuits by means of which the four divisional controls are brought under the central controlling authority at Derby.

It will have been gathered from the description in Chapter XI that the old L. & Y. system differs in many respects from the L. & N.W. Railway and Midland systems, perhaps mainly in the character of the control board, retaining the geographical board which is much favoured by the officers who are used to it, whilst the L.M. & S. Railway on their Western and Midland sections have decided to adopt the time boards as being in their judgment the best standard. Both methods embody and give effect to the principle of direct and visual control, and both appear to give very advantageous results. Future improvements and developments in this far-reaching experiment can only be awaited with interest.

CHAPTER XIII

FUNCTIONS OF THE TRAIN CONTROLLER

THE whole question of centralised telephonic train control is as yet only in the experimental stage, and we have seen how the functions of the train controller necessarily vary in accordance with the particular experiment of which he is in charge, the aim of its originators and also the local circumstances which are applicable. We set out in Chapter IX (page 102) four sets of circumstances which must largely affect the character of the "control" apparatus to be employed, that is, for instance, as to whether it is required for unbooked and irregular mineral and goods trains, or for a long stretch of main line on which important passenger trains run; or whether it is confined to a local branch line service with few trains, or for an urban passenger district with dense traffic.

In this chapter it is proposed to summarise what appear to be the main functions of a train controller under any efficient organisation with a well equipped office. Having the area of control carefully defined, and having accurate and exact information as to all the train movements in that area, the train controller becomes responsible for the moving of trains from point to point as expeditiously as possible at the times required. The specific instructions given him in the official circulars are that he must endeavour to obtain the maximum amount of work out of the locomotive power supplied, so far as freight trains are concerned, by—

(*a*) Using the fewest locomotives possible.
(*b*) Incurring a mimimum of light mileage.
(*c*) Securing the maximum workable loads.
(*d*) Preventing congestion and standing time by regulating converging streams of traffic.

In regard to passenger trains he is to see that the booked arrival and departure times are kept to as nearly as possible.

"But is not this the principal duty *quâ* train working of any general or district superintendent?" is a query likely to be raised by any practical railway critic. Such query can only be answered in the affirmative; and brings to the surface again the feature which has been emphasised in previous chapters that the new train control marks a stage of new method by the co-ordination and utilisation of telephones and other appliances for the assistance of the superintendent in his daily work, making that work, so far as train supervision and working is concerned, more easy, more direct, and more effective.

The train controller therefore becomes one of the principal assistants of the general superintendent, and his duties, as such, the supervision and regulating of train running with a view to securing the movement of traffic as expeditiously and economically as possible. The four points set out above indicate four main lines of effort through which this end can be secured.

To what extent this main function of trains supervision should be enlarged by the addition of other responsibilities, is a matter that must depend on a great many circumstances, and it is a mistake in so important an advance as the centralised manipulation of trains to attempt too much all at once. However, the question of the trainmen's hours is so closely bound up with the whole business of manipulating trains, that in all the more serious installations of telephonic train control that have been brought into operation, it is found convenient and judicious to combine with the supervision of the train working the regulation of the trainmen's hours. This in itself involves very serious problems, because the practice on British railway systems in the past has been for the supervision of the enginemen (i.e. driver and fireman) to be under the locomotive engineer, who has also had the entire supervision of the supply and distribution of engine power for the railway company; and this includes, of course, supervision of all the engine sheds and the repairs of locomotives which are carried out at these sheds. To this particular point it will be necessary again to refer at a later stage.

Let us consider the different circumstances involved in the supervision of train working. The train working arrangements in a local district where there is dense colliery traffic, as in South Wales, on the Tyne, or in Derbyshire, or where there is a large aggregation of factory and engineering sidings, as at Sheffield, Middlesbrough, or Cardiff, are, as has been clearly set out already, very widely different from those of a main running line such as the eastern or western sections of the London and Carlisle track of the L.M. & S., and require considerably different treatment. We will begin by considering a typical central control embracing a long stretch of main running lines upon which all kinds of trains, passenger and goods, booked and irregular, are working.

First of all there is the passenger train service. In connection with this all the principal trains will be immediately advised to the control office on arrival at each stopping station, and their subsequent departure; and these times as received are recorded on train-running sheets. In connection with these main line trains the duty of the controller is first of all to keep watch on the running lines, as trains are approaching, and to see that they are kept clear of any obstructions, such as the occupation of the line by goods trains, or by shunting, when the passenger train is due. This duty should not be a difficult one, in connection with trains running to time, because then the line would normally be clear for the passing of the booked train. It is when a train is behind time that the controller has to get seriously to work. He alone is able to determine what margin should be allowed to admit of a waiting goods train clearing a particular section before the passenger train arrives at its delayed time. The train controller has a much wider vision, through his apparatus, than in pre-control days a signalman could have, and in many cases where, under pre-control working, the signalman could not take the risk of fouling the running line in front of a passenger train, the controller is able to do so, knowing that the risk is practically negligible. In other words, he is much better able to measure the risks, and take advantage of margins for getting subsidiary trains through that would otherwise be delayed.

The eyes of the controller should be always on the watch over the goods trains that are within his control area. Supposing a goods train, which normally has a quarter of an hour allowed at a roadside station goods yard, to detach and attach its wagons, exceeds the normal time, and occupies twenty-five or thirty minutes, the controller should be prompt in enquiring whether the particular train cannot complete its work and move forward. The effect of this constant watchfulness of the controller in the way of speeding up and avoiding unnecessary detentions is important. It is a new feature with no small moral influence for a driver doing his shunting work at a roadside station to feel that his performances are all under the watchful eye of a headquarters office.

The foregoing are illustrations showing how supervision may be exercised with the effect of economising train time under normal circumstances of working. The more that trains can be scheduled at booked times, and the closer they can, in practice, be kept to these times, the less need for any active intervention in supervision. This is clear. In a district or locality where there is a constant string of passenger trains following one another—on the London Underground circle, for instance—and where trains on the whole keep very regularly to their booked times, the main occupation of the controller is that simply of watching and being ready to take prompt action when any train gets out of course. On the other hand, where, as in a crowded colliery district, or near to some busy concentration yard, goods trains are commonly working at very irregular times, and as special services, there close attention is necessary, accompanied with much intervention in the way of suggestions and orders.

This intervention must be carried out without in any way superseding the signalman's ordinary duty and responsibility. The safe working of the trains must remain under the signalman's control.

Passenger trains are always given preference over goods trains in running, and the first principle of all train working supervision is to keep passenger trains running in accordance with their booked times. Ninety-nine per cent. or more of passenger trains work to time-table published schedules, and the function of the controller in the matter comes in to help signalmen and station masters to prevent any unusual circumstances throwing the train out of gear and behind time.

When a complete system such as the L.M. & S. Railway has been brought under the new control apparatus, the main line passenger train control, which cannot very well be segregated in districts, is retained in the central office—in the case in question at Derby—all local trains being left to the sectional controllers. It is considered unnecessary to bring local passenger trains within the control system, so the sectional control becomes mainly a goods control: and, both as regards passenger and goods trains, the principal main line trains are controlled at headquarters.

Moreover, the telephone apparatus of the central control office is regularly made use of for all questions of passenger train working and general supervision, any necessary intervention of the superintendent in the way of emergency or exceptional working that may be required finding the control telephone exchange system of the greatest possible assistance.

This passenger train supervision is accompanied by train recording on forms provided for the purpose, and the train records, made concurrently with the actual running, should supersede a great deal of routine book recording hitherto kept up in the superintendent's trains' office. The chief controller must have a good passenger trains controller as head of the passenger section.

The supervision and control of goods and mineral trains is a still more complex matter, for a much larger proportion of such trains run out of course, and are subject to irregular working day by day, as the amount of shunting to be done at the stations where they are booked to stop varies so much. They are, therefore, much more under the finger and thumb of the control office.

But it is in cases of emergency that the services of the controller become of paramount importance. In the case of an accident, where one or both lines are blocked, and trains have to be sent round by circuitous routes or worked as emergency services from both sides of an obstruction, or in case of main line long distance trains being considerably out of course, then the manipulation of the whole service practically falls upon the controller and his assistants. All the emergency arrangements are for the time being in his hands.

The ordinary routine duties that fall upon the controller and his assistants when a control office has become established for the purpose of train running supervision may be described as follows :

1. First, as regards passenger trains, the running of all the principal trains is recorded on train sheets, and these train sheets become a permanent record, in place of the train recording books of the superintendent of trains' office under pre-control organisation.

2. Reports require to be constantly made to the superintendent himself, in regard to any continuous irregularity in train running, or as to any real difficulty of keeping trains to time.

3. Daily report also must be made of any special circumstances affecting the running of the trains. In the case of any accident or serious emergency, every office on the system affected must be immediately advised.

4. In regard to goods trains, in addition to the continuous watching and issuance of current instructions, in the same way as with passenger trains, any serious difficulty in working trains to time, or preventing delays which ought to be obviated, must be reported to the superintendent.

5. The hours of the trainmen—drivers, firemen, and guards—must be kept within proper limits, and an adequate supply of engine power must be maintained. For each of these two purposes an efficient assistant, with necessary equipment, must be appointed.

The foregoing sets out under five heads the principal duties of a train controller in any large and important control office. These are the duties coming within the true function of a train controller.

There are other duties of a highly important character, some or all of which are delegated to existing control offices. These are functions not necessarily attaching to a controller in his capacity of *train controller* ; they may or may not be introduced, as circumstances dictate. We may distinguish these functions as essential or primary and secondary.

The secondary functions include (1) supervision of marshalling yards ; (2) control over locomotive power ; and (3) rolling stock control (passenger carriages and freight wagons). This will be a convenient place to discuss the bearings of each on train control.

Allocation of Sidings and Supervision of Marshalling Yards.—It is found, in the case of a local control office which directs the working of trains forward over a main line, that as goods trains are staged forward from point to point the question of the allocation of relief or reception sidings when such sidings are provided at intermediate points forces itself on the attention of the controller. It may be that the capacity of two sidings, differing in the number of wagons that each can contain, needs revision, either as regards incoming trains, or trains for despatch, and it is clearly the function of the controller, when he finds that improvement in the allocation of sidings can be made, which will result in improved working, to make suggestions to the proper authority.

A train or traffic controller, let us say, supervising the working of traffic between M and N—neighbouring shunting yards, but 10 or 20 miles apart—will have knowledge of the capacity of each of these yards, and may suggest that on account of relative accommodation at the two yards certain shunting movements in train make-up might with advantage be transferred from M to N or vice versa. The yard master normally only knows the equipment of his own yard, and the controller therefore has superior information on which to found a decision or a suggestion.

In some cases, where the sidings of a marshalling yard are brought directly under the supervision of a control office, some responsibility for the proper allocation of the sidings has been placed upon the controller. It seems very doubtful whether this is a wise course of procedure. If the sidings are extensive, and partake of the character of a marshalling yard, it seems clear there should be a responsible yard foreman, or even yard master, in charge, and he is the person who should receive suggestions from the controller if the latter has any to make, and improvements should take place as the result of conferences between the two. But it would appear as though the controller's functions were sufficiently large, without his undertaking any of the responsibilities which properly attach to a yard master, where that official exists. For the prime responsibility cannot, under good organisation, rest equally with both, and each function would appear to be clearly separable, though closely related.

Let there be full conference in regard to proposed changes or improvements between the controller and the yard master in charge; but let the final decision as to work or equipment within the marshalling yard rest with the yard foreman—this would appear to be the wisest rule.

Control of Locomotives.—The greater facility in regulating men's hours which results from telephonic train supervision must be here noted and described.

In every control office where supervision over the enginemen has been arranged, one member of the staff is told off to watch the men's hours, and to make any necessary arrangements with the locomotive or running section of the department. As each train or engine comes into the control area, this officer is handed a copy of the ticket which gives the time at which the driver, fireman, and guard booked on duty, so that he has in his possession a *résumé* of the hours and work of every set of trainmen who come within the controlled area. These tickets he keeps before him in order of time, and as the eight hours' period on duty is approached, he gets to work to see what arrangements can best be made to liberate the men; if they are not near the home station, or cannot get home within a short time, they have to be sent home by passenger train, arrangements having previously been made with the nearest or most convenient engine shed, or goods guards' centre to supply relief men. Wherever the central control system is to be placed on a permanent basis, some specialised officer of this kind is told off to the duty, and experience soon educates him to become proficient in making what are commonly found to be complicated arrangements.

Whilst this method of regulating the trainmen's hours sounds a perfectly simple step to take, the change involved opens up questions of considerable magnitude affecting the whole organisation of the working services. In the past on British railways all the enginemen, i.e. drivers and firemen, have been under the supervision and in the department of the locomotive superintendent or engineer, who has full charge of the engine sheds where the engines are stabled up and down the system, and these enginemen have been servants of the locomotive department.

In the engine running sheds, the engines are not only prepared for daily service, and cleaned, but they are in these sheds subjected to slight repairs, which means that every engine shed contains a considerable staff of cleaners, steam-raisers, gland-packers and fitters, and various repairers. The question therefore arises as soon as the trains superintendent (in the Traffic Department) takes over supervision of the men and their hours and the payment of their wages—are the men to be transferred from one department to another, and. if so, is the further step of a transference of the running sheds in their entirety to be also taken ? On the old Midland system this transference from the one department to the other has been made *holus bolus*, and the locomotive running sheds and, all the enginemen have come into the department of the general superintendent. This change in supervision over the enginemen is being considered by the different companies in Great Britain to-day, and it is not easy of settlement. It goes to the root of the whole question of the organisation of the operating side of a railway system, and has already been referred to (see p. 159).

Rolling Stock Control: Wagons.—A question of great importance as effecting the work of a control office, is that of the distribution of rolling stock, firstly as regards carriages and secondly goods wagons. The question is dealt with in detail in Chapter XVI, but it must be referred to here as it affects the responsibilities of the rolling stock controller in relation to the train control office. Should the chief controller be responsible for the control of carriages or wagons, or of both, as well as of train working ? The question is difficult and complex, and in Great Britain to-day we have a difference of organisation amongst the large companies, one company having combined their rolling stock supervision and distribution with their new train control organisation: another maintaining a separate rolling stock control independent of their train control office.

The matter of relative responsibility in the allocation of empty wagons when dealing with mineral trains forces itself upon the attention of the train controller much in the same way that we saw the supervision and control of locomotive power must do. Everybody who is conversant with colliery train working knows that a "reciprocal" time table is the only economical method of working, i.e. a train load of empties must be taken in when a train load of coal is brought out. In the case of a colliery whose main traffic is for shipment, the engine picks up its load of empties in sidings at or near the dock, goes off to the colliery, leaves its wagons, and returns with a train of coal. So that the despatch of traffic from a colliery, and therefore the whole question of train working, is largely dependent upon there being a sufficient supply of wagons, and upon wagons being available for supply at the moment required.

Therefore, where central control has been introduced in connection with colliery working, it is found almost essential that a complete record of the wagon stock in the district should be kept in the control office, and that the controller, in order to get his trains of coal moved, should have full power to move empty wagons about, as seems best, to harmonise with train working. In many control offices, therefore, it has already become established that daily (and often at more frequent intervals) a census of wagon stock in the district is taken by the control office, and the office thereby becomes part and parcel of the wagon control system.

Or, to put it another way, even where there is a separate wagon control organisation and controller, the latter must of necessity allow the train controller in charge of mineral traffic a wide discretion in dealing with empty wagons. A wide measure of co-operation, and even in certain localities of joint working, is essential. Considering this from another point of view, a wagon controller's business requires daily adjustment of wagon shortages and surpluses in a locality, and this necessitates movement of empty wagons from point to point, and this empty wagon working is much more readily and economically arranged if the two functions are sections of one control office.

Rolling Stock Control: Carriages.—The question of the carriage and passenger stock controller's position and relative responsibilities is similar to that of the wagon controller. Passenger stock includes, in addition to carriages, luggage vans, horse-boxes, carriage trucks, milk vans, fish vans, and many miscellaneous types of vehicle.

A large railway company will have some twenty to thirty thousand passenger vehicles to distribute. The L.M. & S. Railway's last report recorded 26,603, and the function of the rolling stock controller is to get these vehicles distributed and used as economically as possible. Each railway company in the past has had such an official, known as the rolling stock controller, who gets daily returns as to where the stocks are resting or moving, and makes his distribution upon such information.

With a system of central train control, the question arises whether the train controller should also take over the duties of passenger stock controller. The *pros* and *cons* are much the same as in the case of wagon stock. If the train controller has full responsibility for the manipulation of passenger trains, much advantage arises from his having full control over the stock of which they are composed, and a very little reflection will make this clear. Whilst all the ordinary daily train services run with regular carriage sets, there are occasions, almost every day, when local markets or special events require the ordinary trains to be strengthened, and all such arrangements for special working become part of the passenger train controller's daily duties.

In the most highly developed control offices, where both passenger and goods trains on an extensive main line are controlled, great advantage is found to exist from the controller having the responsibility of carriage distribution, as the adjustment of stock requirements in different districts is then so much more readily and economically carried out. For instance, if a dozen extra carriages should be required for three or four separate market towns, each on a different day in the week, and if the carriage distributor is also responsible for the transfer arrangements for the stock, he may make the same spare carriages do for several days and places, in a way which a local or even a central agent whose duties are simply to allocate stock to specific places, and who was unaware of the train or locomotive facilities for transfer between point and point, might not think of.

It has, moreover, become an instruction, even under an organisation of separate control, that in daily working, when one or two extra carriages are required on a train, because of an unusual and unexpected press of passenger traffic, such carriages for strengthening are to be supplied by the central controller. When it is remembered that these unexpected requirements are a matter constantly occurring over a system with a large area, it is realised at once that the centralisation of the duty of distribution becomes of much advantage, and a combination of the function of distributing carriages economically with that of the control of train movements under the one central train controller would appear to be the most efficient arrangement, care being taken, of course, that in the building up of a central control office the controller is not overburdened by the concentration upon his shoulders of too many new duties all at once.

This word of caution seems necessary, for if a controller zealous in the desire to make his new machinery of control as effective as possible assumes too many different functions —and the three functions we have just been describing are all of them complex—failure through over concentration will almost certainly result.

The real key to the efficient organisation of train control in a centralised office is that the various duties that have been described, viz.:

1. Train control;
2. Arrangement of men's hours;
3. Distribution of locomotive power;
4. Control of wagon stock;
5. Control and distribution of carriage stock;

should each be allotted to a specific and separate officer of equal rank and co-ordinate responsibility, and all working in harmony under one chief, who is competent to act as an assistant superintendent.

In this enumeration of duties that of supervising marshalling yards has been omitted, as under normal circumstances, at any rate, that would seem so clearly to be best centred in an officer whose right place is rather out in the open yard than confined within the walls of the control office. It is interesting to note how this matter has been arranged in the control office at York (see page 128).

Several important features in equipment should be described as part of the necessary apparatus of an efficient control. Of primary importance is the control board, on which all the trains under control are marked up by pegs or tickets, so as to give the controller a visual representation of trains moving in his area of control.

The alternative forms of control board—the geographical board and the time control board and their relative advantages—have been referred to and described in Chapter XII.

No standard token or ticket has yet been suggested: some control offices use simple pegs, some use tickets pegged or clipped on to the board, and the Middlesbro' control ticket described in Chapter X, and used in a clip, has much to recommend it.

The aim in this chapter has been to rehearse the various duties which are coming to be regarded as within the province of a controller and to distinguish between what may be described as the essential functions of train control and the subsidiary or secondary functions which are closely related to it, with a view to giving some indication of the stages by which an all embracing control office in a large system may be built up. There are other duties besides those described in this chapter which might be referred to, as, for instance, the important function of train recording, now usually carried out in an entirely separate office attached to the general superintendent, or again the compilation of train running statistics in regard to loading or punctuality. But such developments as these can only come (if at all) when a control office has become permanently established as a general assistant's office.

It has been found in practice that general improvement may be achieved by a concentration of information under an efficient control master, and of this the following illustration may be given. Imagine the case of a large dock, through which are exported large quantities of coal from adjacent coalfields, as in South Wales or on the Tyne, or the Clyde, or the Humber ports in relation to South Yorkshire. Coal trains are arriving from various points and concentrate at the dock gateway which ordinarily partakes more or less of the bottle-neck type. Twenty, thirty, or forty miles away from the dock collieries are sending out their coals, and always pressing the local railway agents to clear their sidings. In olden days it was no unusual occurrence to have six, eight, or ten trains converging from different running lines at the entrance to the dock awaiting their turn for the dock reception sidings ; and although constant communication was taking place between the foreman in charge of the dockyard sidings and the agents at the colliery ends, it was never known with precision how soon the reception sidings would be liberated for further traffic ; so that many trains had perforce to be sent forward in the expectation of finding reception room. There was then an entire want of co-ordination, and the absence of the means of bringing the necessary information together. This lack commonly led to much congestion.

With a system of central control under which all the trains that are in movement are represented on the control board, it becomes comparatively easy to co-ordinate and regulate the traffic, which is not now allowed to be despatched from the collieries until it is known that there is a free course for it through to destination, i.e. the ship in the dock. This changed method well represents, in so far as goods and mineral trains are concerned, the larger outlook and extended powers of efficient operation which are available for a train controller equipped with a properly developed system of telephones and control board.

CHAPTER XIV

CONTROL OVER LOCOMOTIVES

THE locomotive questions with which a British railway company concerns itself may be divided under two heads, viz. the construction and provision of engines, and the use and distribution of the engine power available. The latter question is that with which a train control office is concerned, as the train service and train working is mainly dependent upon an adequate supply of engine power. The question of construction is an engineer's question, and may be undertaken by the railway company, as it is to a large extent in Great Britain, or it may be left to independent engineering factories, as it is to a very large extent in America and most other countries of the world. The British railway company constructs *or* purchases its locomotives according as the circumstances at the time of requirement indicate to be the wisest and most economical policy.

The writer's first introduction to the importance and possibility of mechanical or graphic aids to supervision over locomotive distribution was many years ago on a visit to Chicago, where, being introduced to the mechanical engineer—"superintendent of motive power," he was technically called—of one of the larger railway companies in the U.S.A., there hung upon the office wall, in front of the superintendent's desk, a very impressive representation of his total engine stock—some 1,511 locomotives—each typified by a coloured tally (a small metal disc), every locomotive being shown by colour—white, green, or red, according as to whether it had run (1) under 70,000, (2) between 70,000 and 100,000, or (3) over 100,000 miles since it last left the shops after heavy repairs. According to the preponderance or the scarcity of the red discs amongst the total stock displayed could be visualised in a glance the position as to the amount of heavy repairs requiring to be undertaken on an early date : and a general idea obtained of the daily condition of the locomotive stock. But whilst this does undoubtedly enable the onlooker, be he visitor or responsible official, to get by glimpse *some* appreciation of the position of things, it is only a glimpse or general idea, and the officer in charge must supplement this general presentation by much detailed information from a variety of sources.

It is more than twenty years since the writer saw this graphic display in Chicago, and he understands that this method, interesting as it was, has now been superseded, and given place to a system of survey by card index or its equivalent in a periodical official return. One company has been good enough to furnish the following specimen of a blank return (Fig. 38) on which is recorded the condition of each engine. These blank forms are filled up by the local shed foreman at the beginning of every month, one for each engine, and sent up to the general superintendent of motive power, so that this superintendent has a complete record filed in his office of the condition of all the locomotives that are out in traffic.*

In Great Britain, our organisation is undergoing change, and as has been already pointed out, there are two entirely different organisations for the supervision of the locomotive power available for daily working.

Under the old-established and traditional method, the locomotive department of each company was entirely responsible for the building or purchasing of engines, for the maintenance of an adequate number of engines to do the work required by the traffic department, for keeping the engines in good working repair, and for their proper distribution as between the different local engine depôts. Under this old organisation, the whole of the enginemen, drivers, and firemen were attached to the locomotive department, and under the supervision of the chief of that department, known as the locomotive superintendent or mechanical engineer. All the local engine stabling depôts, and the shed foreman at each place with his subordinate staff (steam raisers, fitters, repairers, etc.), were also a section of the locomotive department.

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* For information in this paragraph I am indebted to Mr. Donald Rose, the European Traffic Manager of the Illinois Central Railroad.—*Author.*

CONDITIONS OF LOCOMOTIVES.

..............................Railroad Co.

..............................Division..............................Shop Month of..............................192.......

Engine Number.	Miles Since Last General Repairs to	MILEAGE OF FLUES.		Cost of Last General Repairs.	Date.	Shop.	Months Service Good For.	NEEDING REPAIRS.			BOILER WORK REQUIRED.
		Full Set.	Part Set.					In Service.	In Shop.	Awaiting Shop.	

FIG. 38.—CONDITIONS OF LOCOMOTIVES: AN AMERICAN BLANK RETURN FORM.

Under more recent developments, it has been found an advantage to have the available engine supply attached to the superintendent's department, leaving to the mechanical engineer the responsibility of maintaining the stock in good order, as well as maintaining it in adequacy by building or buying new stock as may be required. Under a régime of this kind where the local engine depôts are under the control of the general superintendent of the line, the latter official not only has supervision over all the enginemen, but he has also to see that all light repairs which can be attended to at the local depôts are properly carried out; and this necessitates a careful frontier line being arranged within which repairs to the engine may be undertaken locally by the traffic or running department.

It will be realised at once that to make the general superintendent who has charge of the train working all over the line responsible also for keeping the engines in traffic in good order, and for supervising the enginemen, is adding a great deal to his responsibility, necessitating a more technically educated staff with some engineering knowledge.

The distribution of locomotive power day by day, and the allocation of each engine unit to its appropriate place and work, is one of the most responsible duties which attaches to any railwayman, for each locomotive will represent a cash value of anything from £1,000 up to about £10,000 or more each; and it is upon the locomotive—the engine unit—that the whole function of transport depends.

Every engine then needs to be card-indexed—for every engine one card—describing its main features, and the set of cards representing the engines in each local depôt should be kept in the control office for reference so that the type of engine in its main mechanical features can be ascertained at any moment; whilst a second set of forms has to be used to record the daily work of each engine. From this second set of records are made up the statistics as to the work and behaviour of each engine per month, or per year, as may be required.

We have already explained how the cards representing wagon or carriage units of special types are entered up, and stored in cabinets in easily accessible manner; and how efficient and effective for its purpose this record is. For a record of the engines the card system is equally effective : and it is even more necessary, for there is the important difference between the engine and the carriage or wagon stock that the former is a moving unit accompanied during movement by two men (enginemen). The work of these men has to be carefully supervised and watched from a control office, and the engine has to be kept constantly in good working trim.

It has been already explained how the supervision of the men's hours not only constitutes one of the leading functions of the control office, but that it was the necessity of better machinery for such supervision which more than any other factor was responsible for bringing the new method of control into existence. It is therefore unnecessary to devote time or space to this question in this chapter.

INDEX CARD TO ENGINE DETAILS.

Engine No. Class Type

Cylinders, size of		SHOPS.		
Class of boiler		In.	Out.	Where.
Boiler pressure, lbs. ..				
Wheel base				
Driving wheel, diam. ..				
Heating apparatus				
Back-weatherboard ..				
Tubes, kind of		Allotted to		
Tank capacity, galls. ..				
Brake				
Water-scoop				
Sanding apparatus				
Superheater				

But the method of carding or recording the locomotive and its daily work should be here explained. Let us take the Derby office method by way of example, for here all locomotives in traffic come under the supervision of the general superintendent.

First of all is the index card for every engine : a copy of this card is set out above. It will be noticed that it records for each engine the leading features, e.g. size of cylinders, class of boiler, steam pressure, wheel base, and so on.

Every Monday morning the stock of engines, and the condition of each, is checked by a return from every depôt to the contrôl office. This return shows the position of every engine at that time, both passenger and goods, with the condition of each, and the percentage at each depôt in shops for repair. All this information is essential in order that the control staff may arrange the daily train working effectively and economically.

Let us recall what this daily arrangement of locomotive power involves. At any important centre there will probably be six, eight, or ten varying directions of line, each being controlled or limited by different gradients, so that the same engine, which on a fairly level gradient would take 60 or 70 wagons, would on another line have its work fully cut out to manage 25 or 30. As a matter of fact for heavy grade work a differently constructed type of engine is desirable.

Then there is the distinction between shunting engines and train engines as well as between passenger, goods, and heavy mineral train locomotives: and lines with very bad curves may require an engine with specially short wheel base. All these and many more factors come into consideration in making the allocation of engines for each day's work, or for any special trip or shift of duty that may be required. And economy is largely a question of suitable allocation of engine power. It is here where judicious control may be exercised—the equating of the types and capacities of the engines available to the physical circumstances of daily work.

In days gone by the matter was very simply, if not economically, arranged by a daily, or nightly, consultation between the engine shed foreman and the local traffic inspector in charge of the working of trains. In the case of all regular train working, where the scheduled time-tables have to be given effect to, no special arrangement is necessary, unless from any cause some train is not required and has to be cancelled; but in the case of all irregular traffic these two officials would meet after the day's work, and the traffic representative would tell the locomotive foreman just how many engines should be provided for the trains of to-morrow, and the class of engine would usually be selected by joint consultation.

In regard to the spare engine stock the traffic representative would have no information. He would feel he must always make the best use, and the longest that he dare risk, of the engines which he knew were available; and long hours of the enginemen were often the direct result.

Under the modern régime as at Derby the whole of the available engines over a large area are under the direct control of the same officer who is responsible for arranging the trains to be run, and he has the knowledge both of traffic to be moved and engines to move it, and he can make prompt and effective arrangements: and when a particular type or class of engine is required for a special job, the controller can "tell off" the required locomotive from any depôt by simply consulting his card records of where the engines of any particular type are stabled.

We have noted that a locomotive differs from a carriage or wagon in that it is itself capable of movement. The very fact that this is so carries with it certain factors, themselves requiring supervision and control. These include the amount of fuel used in the generation of its power, and the daily renewal and cleaning of all working parts.

Varying devices for control over the consumption of coal, oil, and water are, or have been, in operation, the old-fashioned bonus to drivers varying inversely in amount in accordance with coal consumption—i.e. a large bonus when coal consumption is kept at a low point—has now been mainly discarded, as tending to reduce the engine power and its effectiveness by an undue restriction of coal consumption.

Another plan widely resorted to is that of posting up in the engine shed the performances of each engine at the end of a month or week with particulars of loads hauled, coal consumed, etc., so that all the drivers concerned may know of the achievements. The natural aspirations of men to show up well in a record exhibited publicly is an incentive to each to make the best performances possible.

Reports come to hand from America—see *Railway Age*, September 5, 1925—that during the current year the coal consumption on locomotives in the U.S.A. has shown a lower record than for many years. The consumption record is measured, and published in the Interstate Commerce Commission Statistics, in the number of pounds consumed per 1,000 gross ton-miles hauled by the engine. It is, of course, not only efficiency in manipulation on the part of the engine-driver, but also the weather conditions which affect consumption, which is always lower in summer than in winter. Taking the figures for June year by year since 1921, they show as follows :

June	1921	..	145	lb. coal per	1,000 gross	ton-miles
,,	1922	..	141	,,	,,	,,
,,	1923	..	*146	,,	,,	,,
,,	1924	..	135	,,	,,	,,
,,	1925	..	127	,,	,,	,,

It is stated that the making of the new low record for the summer months was due entirely to the impovement in locomotives that is constantly going on and to improvement in the supervision of employees and in the way the employees do their work.

We have seen that in the Derby control office the weekly return of the geographical allocation of the engines provides for information as to the condition of the locomotive, so that the superintendent may with this knowledge make such arrangements with his mechanical engineer as are necessary to meet not only the condition of the stock, but also the capacity of the shops to cope with the work involved. Indeed, it is usual for a careful programme to be arranged under which general or heavy repairs to stock can be undertaken at fixed periods determined according to the rate at which the shops can be kept steadily at work, and aimed at bringing each engine in after it has had either a definite time period since its last overhaul or more usually after it has run a standard number of miles in service (50,000 or 100,000, or whatever figure may be considered a reasonable number for each class of engine).

The degree in which the general superintendent of a large system has deputed to him responsibility for the engines which are daily under his control in traffic varies much as between company and company.

The gradual extension of the system of train control

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* Affected by shop employees strike.

which we have been describing brings the question of distribution of responsibility directly to the front, and the question is naturally asked whether the supervision of a large stock (running into many thousands) of locomotives does not necessarily require a trained mechanical engineer if the supervision is to be really efficient? There are two ways in which such a question may be answered. Firstly, it is pointed out that when the locomotives are under "traffic" supervision, the whole of the engine sheds also come under that supervision, and each shed is supervised by a trained engineer in the person of the shed foreman or depôt "inspector." This is, of course, important and essential, for cases have occurred where a driver has been known to refuse to take instructions from an acting supervisor who is not engineer enough to understand the technical construction of an engine. There is no serious difficulty in the supervision of the shed foreman by a general superintendent, although on mechanical matters of a technical character the superintendent will have at times to be guided by rather than to guide his subordinates.

A second solution to the problem is that whilst the entire supervision of the distribution of the locomotives when at work is with the general superintendent, the local depôts where the engines are stabled remain under the authority of the locomotive department *in so far as the keeping of the machines in good working order is concerned.* Under such arrangement the shed foreman or depôt inspector necessarily becomes a joint functionary responsible to the mechanical engineer or locomotive superintendent for repairs and for all technical or mechanical points which may at any time be raised; whilst he is under the orders of the general superintendent in regard to the daily utilisation of the stock of engines. This joint supervision has the great advantage of leaving entire responsibility for engine repairs, light *or* heavy, with the mechanical engineer, whose function it is primarily to build and maintain in good order the stock.

CHAPTER XV

CONTROL ON THE UNDERGROUND

The aims of control on the London Electric and Underground Railways are very different from those which have been set out as pertaining to the large railway systems. Whilst it is true that in number of passengers the volume of traffic is greater than most of the larger companies, yet as regards most of the lines the London railways are free from the complication of an irregular goods traffic—the factor which first led to the introduction of the new train control on the (old) Midland.

The main aims of control on the Underground are to work efficiently a very heavy passenger traffic and to secure safety in working.

During 1924 upwards of 400,000,000 passengers were carried on the London Underground Railways, and the mere fact that about forty trains follow one another in each direction *in one hour* at such busy points as Charing Cross or Camden Town is in itself a sufficient indication of the need for the adoption of every precaution against accident that human ingenuity can devise. Mechanical and automatic control devices have been introduced more freely on the London tube railways than on any of our other railways.

The whole of the 43 miles of underground railway of the London Electric Railway Company are under a central telephone control system, with headquarters at Leicester Square, which station forms a sort of clearing-house, as far as the operating of trains is concerned, for all the L.E.R. lines. (Incidentally it may be mentioned also that the working of all the L.G.O.C. buses—a fleet of 3,500 machines—is under control from an adjoining office. See pages 81–82.) The distinguishing features of the London tube railways from the point of view of control are in the first place that the trains are all passenger trains running mainly at scheduled times; the trains on "the circle" run at regular intervals, and these intervals (5 minutes or 3 minutes as the case may be) have to be maintained. With the exception of a few junction stations, no junction or relief siding difficulties have to be met with. The absence of goods working is of greater importance in the simplification of signal working than would at first sight appear, for wherever goods traffic is worked there must be a goods station, and a goods station involves a junction with the running passenger lines. It is these junctions that constitute the complications of signalling, and simplification of signalling largely depends on the elimination of junctions, or, as they are called, "openings," in the main line. The first and prime essential in the London train control, however, as in all train control offices, is an efficient telephone exchange, and in this respect the office at Leicester Square is of the highest excellence. The traffic controller has his room adjoining the telephone exchange and he is able to get prompt communication by means of a separate line to each station on the system, and by a direct line to the top station or station master's office at each station (about 450 in all). The controller has also provided in his own office a private telephone board giving direct connection to some 60 of the more important stations or control points, and he is able to immediately connect himself to any one of these points.

In case of any disorganisation of traffic or in any emergency of any kind, the machinery of control is immediately called into play. On the day of the writer's visit, owing apparently to some special inrush of traffic at Waterloo, the underground train was delayed there for 2½ minutes, its normal stopping time at that station being 15 seconds. That delay would cause several trains behind it to be held up and delayed, and each train afterwards would, if possible, have to be quickened up, and follow more quickly on the heels of its predecessor. The writer was told that this 2½ minutes' delay would probably throw six following trains out of gear before the schedule time was overtaken again.

The key to satisfactory working on the Underground

Electric Railways is the maintaining of frequent and regular "headways"[*] between trains following each other. At a busy point where some forty trains follow one another in the hour the average headway is 1 minute and 30 seconds, and one of the principal mechanical contrivances in the Electric Railways control system is the recording clock for indicating the headways. At all the principal stations there is fixed as the train leaves the station a headway clock or dial indicator, which records automatically the time since the last train went past it. If this clock indicates 4 minutes, it shows that 4 minutes have elapsed since the previous train went by, and as another train passes the indicator the pointer is released, automatically returns to zero, and again begins from that point to register the time till the next train comes by. At any of the stations the waiting passenger may tell by the automatic dial how long it is since the last train went by. But the main use of this indicator is for the controller, and in the control office is a duplicate or exact replica of the station dial recorder which the controller can switch on to certain of the dial indicators at the stations. As a matter of fact, he will select a station at his discretion for test purposes, switch his own dial "into gear," and immediately his dial indicator is synchronised with such station indicator as he chooses to select. This he does for purposes of test. If a steady and even headway of train after train is maintained, the maximum number of trains can be worked, but if a headway of 3 or 4 minutes occurs when a maximum of 2½ only is expected, the controller knows something is wrong, and steps must be taken to bring the working back to the normal, or a record will be made that another train might at this particular time be worked in. The mechanism is so arranged that if the controller is testing to ascertain whether any 3 minutes' headway exists at a particular station—say Charing Cross—a bell automatically rings to draw his attention should a 3-minute interval be recorded, so that his mind is not taken off his other duties to watch the Charing Cross dial. An audible intimation is given him. It functions as he requires it, and automatically draws his attention each time the given headway is exceeded.

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[*] The "headway" is the interval between trains following one another in the same direction.

There is also a second clock dial or disc which is used for the purpose of recording the density of trains over any particular track at varying periods in 24 hours. It is simple and ingenious. The disc revolves under a stamp or hammer, which, being automatically actuated by each train as it passes a given point, stamps the margin of the disc exactly in proportion to the number of trains, and as the disc is graded and revolves evenly, going round once in 24 hours, and each bar represents a train, a graphic record is obtained at whatever station point on the line the apparatus may be set.

In Fig. 39 is given a picture of this disc, which has taken a record at St. James' Park.

The telephone switchboard and exchange in the Leicester Square office has some unique features. There is no noise of ringing, a call being indicated by the exhibition of a red disc at the switch of the particular station which has put in the call.

Automatic signalling of trains has from the opening of the electric tubes been the method of signalling employed. As each train passes a signal post it locks on the signal behind it against any following train (by a method of track circuiting), and holds the signal at danger as long as it is in the section, releasing the signal when it passes the signal post into the next section in advance. Each train thus signals itself, and signalmen are eliminated. The men have only to be installed at places where there exists any junction in the running line.

It may be mentioned in this connection that when the Metropolitan conversion from steam to electric traction took place a considerable reduction of signalmen employed was the result. Between Praed Street and Aldgate Stations, where there had been 49 block sections, the automatic signalling which, following electrification, was installed two or three years later, provided 68 block sections, this increase of 19 sections representing an increased capacity of the line for 40 per cent. more trains, and the signalmen were at the same time reduced in number from 86 to 27, 645 levers being reduced to 362.*

Whilst the adoption of the block system and the interlocking of points and signals are devices for securing trains against accident by preventing two trains being on the line at once, many accidents have occurred through drivers running past signals against them, and so getting into a section already occupied by another train. This contingency is guarded against on the London Underground railways by an automatic stopping device, and if a driver by any mistake runs past a signal set at danger against his train, contact is made with a track treadle or train stop, which is placed in position by the mere fact of the signal being at danger, and the contact made with the treadle opens a trip-cock and automatically puts on the continuous brake, and at once brings the train to a stop. A train going *at full speed* is by this automatic stop device pulled up and stopped in about 400 feet. The illustration above shows the nature of this device.

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* From a paper read by Mr. Willox at the Institution of Civil Engineers, March 14, 1922.

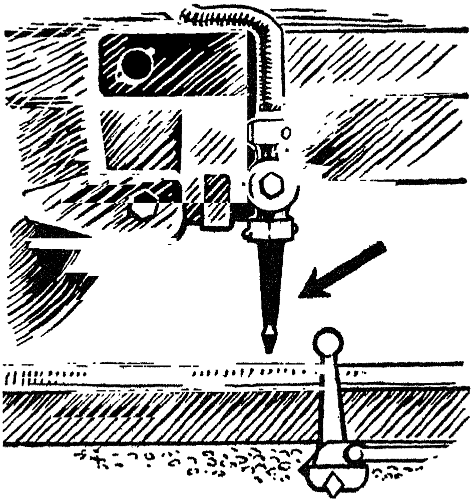

Fig. 40.—Train Stop and Trip-Cock.

In case of any emergency requiring current to be cut off there are arrangements in the tunnel allowing this to be done and enabling telephonic communication between the train staff and the sub-power station. Two copper wires are provided over the whole length of the tunnels, to which the motor-man has access, and by grasping these and bringing them into contact by tight pressure an emergency device operates in the sub-station, cutting current off the track in question and sounding a special alarm. The sub-station attendant then takes up his telephone receiver, and as the motor-man who gave the alarm call has by this time clamped on to the emergency wires his portable telephone he can arrange with the sub-station attendant what is the next step to be taken to meet the emergency and to put things right.

The device known popularly as the " dead man's handle," so commonly in use now on electric tramway motors, is in regular operation on the Underground railways. As the motor-man keeps his hand on the control handle a switch is pressed down when the train is moving. The removal of the motor-man's grip of his control handle—in case of his being stricken down from any cause at his post—causes an opposing spring to be released and throws the lever to the off position, automatically cutting off the current and applying the brakes.

One further precaution is taken in this connection, and automatically given effect to, which secures that a sufficiency of brake power is maintained. An air pressure of 45 lb. must be maintained in the brake pipes or the train will not start. An automatic device prevents the motor starting with less than its safe minimum brake pressure: so after a stop the driver must always charge up to the necessary pressure for safe working. There is no need for a tell-tale gauge; the train simply will not start if a sufficiency of air pressure is not in the pipes.

A leaflet describing the system of safety " control " on the Underground issued officially by the company in 1911 so carefully sets out the precautions taken, and the diagram so clearly sets out the arrangement of signals, that it is set out in full in Fig. 41, with the leave of the managing director. Since this notice was issued (in 1911) many further improvements and precautions have been introduced. Some of these have already been referred to.

In order to control and keep moving the crowds of passengers, escalators, i.e. moving stair-cases, were introduced many years ago and are being widely extended, at great cost. Passimeters, which control the queues of passengers and bring ticket checking and ticket issuing under the control of one office—the booking office—which is equipped with automatic ticket issuing machines, are being introduced at many stations.

These last named innovations are all in the direction of a more rapid distribution of tickets, and aimed at reducing or preventing congestion at the booking office windows.

The new methods of control on the Underground have reference not only to the efficient working of passenger trains, but are directed to the regulation of the very heavy crowds of passengers which use the stations at the daily rush hours, and also—and this primarily—to the attainment of the maximum degree of safety in working.

By mechanical appliances and automatic devices of the kind we have been describing the London Underground Electric Railways maintain an immunity from accidents to passengers which is probably unequalled the world over, and justifies the claim that has sometimes been made that on any quantitative method of measuring risks there is no safer place in the world than a seat in one of the Underground trains!

CHAPTER XVI

THE ROLLING STOCK CONTROLLER

I. WAGONS

IN illustrating in our first chapter the directions of control in a railway system, four heads were referred to: (*a*) The sorting out and despatch of packages at a goods station; (*b*) daily distribution of carriages and wagons; (*c*) the economical distribution of locomotives; (*d*) manipulation of train working. The complexity of control grows with these four heads in ascending ratio, and having now dealt with three of these directions of control, we proceed in this chapter and the next to deal with the moving stock upon the railway systems—the wagons and carriages. In describing the several control offices we have necessarily had to discuss this question in some measure, but it must now be dealt with more in detail, as "rolling stock control" is an essential factor on all railway systems, whatever be the method of train control.

A large company in England owns about 300,000 wagons, with probably as many again belonging to private traders running indiscriminately amongst its own stock. In England and Wales there are altogether some 1,400,000 wagons of which 750,000 belong to the railway companies.

The problem from the point of view of the management of a railway company is how best to secure the efficient distribution of the 300,000 wagons, so as to get the utmost use and advantage out of each wagon. At any given moment, say, eight o'clock in the morning, one-half of these wagons at least will be under load, either being loaded at sending point, unloaded at receiving point, or in course of transit. A certain number will have just completed their journey and discharged their loads, and will be waiting as empties for their next journey ; there may be an accumulation of empties at certain points : there will certainly be many points where, for the conveyance of goods awaiting transit, wagons are required.

The wagon controller has first to collect information as to (1) where all his stock is and what it is doing, (2) what is the requirement of each station and forwarding point, and then arrange for the distribution so as to meet his requisitions as fully as possible, and with as little as possible of unnecessary haulage of empty stock. This is the daily problem before the controller, and there are various methods by which the work is given effect to.

One of the simpler methods is perhaps that in force in the U.S.A., where every railway company has its "car accountant" who is charged with the duty of watching each individual wagon, following its journey day by day over the many thousands of miles of track covering the surface of the American continent, and using his efforts to get for each wagon a maximum of service. This service is measured in miles, i.e. car miles.

Under this arrangement, a ledger is kept for every wagon or rather a page in a monthly ledger, each page having the dates of the month (1 to 31) in the left hand margin, and opposite each date a space for the record of the day's work and mileage. Thus one page might be illustrated somewhat as shewn on page 210, at the top of each being recorded the number of the particular wagon referred to.

It must be understood that this is an entirely suppositious case—a blank form filled up haphazard, and merely to give an illustration of the way in which the car accountant principle is worked out in the U.S.A. A very heavy amount of bookkeeping is involved in keeping up these records as may easily be understood, but it is considered fully worth while ; for the freight car equipment of a big railway company represents a very heavy expenditure, both in capital cost and annual upkeep, and the method of the car accountant's supervision is on lines somewhat as follows.

He knows what is a good average figure of monthly mileage to secure in the running of each car, and with such cars as secure very small mileage returns in the month enquiry as to the reason why is at once instituted. Supervision is being continuously exercised with a view to getting the mileage results of every car in service increased, and the mere fact that all the agents concerned in operating or in any way handling the cars know

BOX WAGON (GONDOLA CAR) No. 44,621, BOGIE TRUCKS, WESTINGHOUSE BRAKE. TARE, 12 TONS 6 CWT.

Date of Month.	Particulars as to Service.	Location between 9 and 10 p.m.	Mileage Secured in each Day.
1	Goods terminal at New York ..	New York	—
2		New York	—
3		New York	—
4	Labelled City to Chicago	En route	200 E.
5		En route	350 E.
6		En route	300 E.
7	Arrives Chicago	Chicago	120 E.
8	Loading up	Chicago	—
9	Labelled for Pittsburg	Chicago	70
10		En route	250
11		En route	250
12	Arrives Pittsburgh	Pittsburgh	80
13	At Pittsburgh	Pittsburgh	—
14		Pittsburgh	—
15	Loaded out for Harrisburg	En route	200
16		En route	200
17	Arrives at Harrisburg	Harrisburg	—
18		Harrisburg	—
19	Despatched to Philadelphia	En route	50
20		En route	100
21	Arrives Philadelphia	Philadelphia	20
22		Philadelphia	—
23	Load discharged	Philadelphia	—
24	Sent private siding for reloading ..	Philadelphia	5 E.
25	Reloading to Atlantic City	Philadelphia	—
26	Despatched to Atlantic City	Atlantic City	66
27	Unloaded and returned to New York shops for repairs	Atlantic City	—
28		En route	100 E.
29		En route	100 E.
30		En route	100 E.
31		En route	71 E.
			1,286 Rev.† 1,346 Empty

† = Revenue.

that "the eye of the boss"—to use an Americanism—is upon them has a stimulating effect.

If the wagon stock of an individual company is 300,000, to deal with the whole stock in this way would apparently require *for each month* a ledger of 300,000 pages; and stated in this way it seems to be an almost impracticable problem. But in these days of loose leaf registers and card systems a ledger is a very adaptable commodity, and anything that will considerably improve the working arrangements and effective distribution of railway wagon stock is worth a trial. If the magnitude of the task from the accounting point of view is too great to deal with the whole stock, it will be found probably that for a certain proportion—the more expensive kinds of stock, e.g. all trolley wagons, 50-ton wagons, gunpowder vans, and such stock as cattle wagons, passenger saloons, etc., can be dealt with satisfactorily in this way, a card system probably being substituted for the book register or ledger. This is in fact being done by British railway companies, as part of their control system, as will be explained.

Summary. American and Canadian Freight Cars during years ending June 30, 1909, 1911, *and* 1912, *and Average Car Load* 1912.

Month.	Average Miles per Car per Day.			Average Ton Miles per Car per Day.			Average Tons per Loaded Car.
YE 30/vi	1909.	1911.	1912.	1909.	1911.	1912.	1912.
July ..	20·0	22·8	21·9	275	323	317	21·1
August ..	20·0	23·2	22·9	292	358	350	21·6
September .	22·0	24·2	23·8	320	375	368	21·6
October ..	23·8	24·8	25·0	346	376	382	21·1
November .	23·5	24·3	24·4	341	385	376	21·9
December..	22·3	22·7	23·4	332	349	361	22·5
January ..	20·9	22·1	20·4	293	331	325	22·8
February ..	21·7	22·6	22·9	306	330	370	22·6
March ..	22·7	23·2	24·5	330	332	389	22·4
April ..	22·4	23·3	23·3	310	317	340	21·2
May ..	22·5	23·7	23·7	304	338	350	21·7
June ..	22·4	22·9	24·1	314	338	366	21·8

FIG. 42.—FREIGHT CAR PERFORMANCE IN U.S.A.

Above is given a statement taken from the American official records of the freight car performances for the years ending June 30, 1909, 1911, and 1912. The statement, which is complicated by the inclusion of the Canadian railway wagons with those of the United States railways, will be found interesting as showing one of the statistical surveys made use of on the other side of the Atlantic.

As a matter of interest, we give also for what the figures are worth similar figures as to the average wagon miles travelled per car per day, and the average ton miles hauled per car per day for the two large British companies in 1924. They show:

1924.	Number of Wagon Miles per Wagon per Day.	Number of Ton Miles Hauled per Wagon per Day.
London & North Eastern Railway ..	20·6	73·3
London, Midland & Scottish Railway ..	22·8	84·5

This comparative table may serve to bring our minds back to methods in our own country.

Where the functions of rolling stock control have not become absorbed in the central train control office of the superintendent, there exists a rolling stock controller in charge of carriages and wagons respectively, whose function is to discharge the duties and responsibilities already described. He is styled "wagon controller" or "carriage controller" according to his duties; or simply chief of the wagon control or carriage control office.

The rolling stock controller is a functionary usually acting under the direction of the general superintendent, and his supervision is exercised through the district (or divisional) superintendents, over a large number of subsidiary wagon depôts. We will consider first the freight wagon stock, and assume eight districts and seventy-two depôts (an average of nine depôts to each district.)

Control is exercised from the head office by a daily survey of the position in regard to stock, information being obtained under the following arrangements. A census is taken at every station and wagon centre daily at noon. At 2 o'clock each day a return is received at the central office setting out precisely how each district is circumstanced as regards requisitions for wagons, and its surplus or shortage of stock to meet the demands for traffic. It is the function of the control office to supply the shortages of one district from the surpluses of others; or when there is an all round shortage to determine who is to go short, or to what extent the shortage can be equitably shared by all applicants for wagons. In case of any continued period of shortage, consideration has to be given to the question of getting increased supplies of stock by borrowing, or by getting traders to unload and discharge wagons more quickly; and in case of surpluses to consider whether a definite number of wagons should be withdrawn from traffic and stored away in sidings. Periodically, the stock controller must consider with his superintendent the question of adding permanently to his stock to meet increased or increasing traffic.

To adjudge adequately what is the need for an increase of stock carefully selected statistics and graphs are essential. The rolling stock controller will keep a graph or diagram which shows day by day every month the extent of surplus or shortage of all his principal classes of wagon: the wagon stock being equated to the amount of traffic in tons or ton miles. An illustration of how such a graph is drawn up is given in Appendix VIII.

This graph, however, is for one month only, and is useful as showing the fluctuations for current purposes *within the month*, the purpose for which it is compiled. But having regard to fluctuations of railway traffic from varying causes, a survey over a few years is essential before the adequacy or otherwise of a wagon stock can be determined.

Many traffics are seasonal, causing a temporary urgent demand for wagons leading to a shortage extending perhaps for several weeks, but not longer; and after a protracted strike or other emergency the working off of arrears of traffic may also lead to a temporary very large demand. But these passing circumstances must be distinguished from an increased demand arising from the natural development of traffic which normally takes place over a course of years, or at any rate which did prior to 1914: since the war period circumstances in regard to wagon distribution have been very abnormal and normal progress has been arrested. But this only increases the need for comprehensive surveys.

The figures of the monthly graphs must be converted into monthly averages, and the twelve months of each year converted into a graph for the year: then an illuminating record of the wagon position compared with traffic handled is presented, forming the best possible basis on which to found an opinion as to adequacy or otherwise.

But we must come back from the point of view as to whether the general supply as a whole is adequate to the daily function of the wagon controller which is to secure an efficient distribution of such stock as he has at his disposal. This can only be done by daily survey—or perhaps twice daily—of the whole position, as to requisitions for wagons and wagons on hand immediately available for loading purposes.

It has been already stated that the rolling stock controller obtains a daily return from all points of despatch and unloading, and from all stations a statement of wagons on hand as well as of wagons wanted for immediate despatch of traffic. At 12 o'clock midday a census is taken at each station, and a return of (1) number of wagons on hand, (2) number needed to load up to-morrow, (3) number available for this purpose, (4) balance—shortage or surplus.

This return is sent from the station to the local depôt: the local depôt agent, after adjusting matters in his own district, sends a similar return as to his district to the district superintendent, who in turn, after arranging for his own district, sends on his wagon return to the general superintendent's central wagon control office.

This is the *daily wagon report*, and it is forwarded to the head office from the district superintendent's office conveying a summary of the position in each district. The district superintendent in turn has received information (1) as to traffic to be moved, and wagons required therefor from the different station masters or goods agents, and (2) as to wagons on hand from the station masters and wagon depôts.

It is then the business of each district superintendent to adjust the balances within his own district first, transfering wagons as necessary from points where they are standing as "empties" to the stations requiring them with as little haulage movement as can be arranged, and with the utmost despatch practicable.

The total balance in the district, whether as surplus wagons on hand, or as a shortage which needs to be made up from elsewhere, is then reported to the central wagon control office, who take such action as is necessary to adjust supplies between the districts.

To give the exact information which the wagon control office requires the return must specify the wagons "received loaded" on the day the return is made out, and also on the day preceding the date of report; and as regards wagons required—whether they are wanted for despatch to-day or to-morrow or later: and of course the types of wagon must be specified all through, though for the general station traffic it is the ordinary open wagon, and the 10- or 12-ton box or covered wagon which are the two standards with which mainly the return is concerned.

As this return is the foundation return of the wagon controller's business, a copy of one of the standard forms—the daily wagon report—is set out in full in Appendix XI. This report passes daily from each station to the wagon depôt; from each wagon depôt to the district superintendent, and from the district superintendent to the central wagon control office. Most of the wagon descriptions are referred to by code word, and the columns of the return are also coded so that the telegraph may be freely used, as of necessity it must be, between stations and depôts.

An important factor in considering the summary return at headquarters is how many wagons have been loaded out to other companies' systems, and how many wagons have come on to the system either empty or loaded with goods from other railways: these figures are carefully watched in the control office, and action taken as may be necessary. There are of course inter-company understandings and arrangements providing for balances of stock to be fairly adjusted between railway companies, the necessary adjustments being made by the clerical machinery of the railway clearing house.

The "pool" or common user arrangement of wagons under which, instead of each company rigidly keeping possession of its own wagons, an inter-company arrangement has been made providing for common user of the wagons as though it was one joint stock has vastly affected the whole problem. Under the old system when a given wagon ran off the owning company's line it had to be returned as soon as possible, often a very long distance of empty running; and for every mile it was used with load away from its own system the using company paid the owner an agreed fixed figure per mile run. All these accounting adjustments disappeared when the pool came into play, a simple account of the number of wagons passing on and off each company's line being carefully recorded by the central authority, and debited or credited against the company concerned until the number on loan is returned, or the surplus received by a company is duly wiped off.

There is no need here to enlarge upon the advantages and implications of the pooling system, which has been admitted on all hands to have accomplished great economies; but it has been necessary to refer to it in describing preliminarily the area of operation for control of rolling stock.

The foregoing in very general outline represents the method by which supervision over the large stock of a railway system is being maintained,—the system of the car accountant in America, and the method of a wagon or rolling stock controller in Great Britain.

As the size of a railway company has grown, and with it the number of wagons forming the stock of a railway company, the organisation has become ever more and more complex. The greater the size of a company moreover, the greater is the variety of types of wagon, and every type needs special consideration in the daily distribution. A reference to the blank daily return of wagon requirements (Appendix XI) is sufficient to show the great variety in descriptions of wagon, each of which has to come under consideration in the daily review.

It is when one comes to handle the detailed requirements of every individual station that one realises the "jigsaw puzzle" character of the arrangements which it is necessary to make in daily administration, and the supreme importance of having the control machinery of the most efficient character.

Leaving out of account for a moment all specially constructed vehicles (for we shall deal with them later on) what are known as ordinary covered or open wagons are distributed to meet the following multifarious circumstances. Every day the large ports of the country—London, Hull, Liverpool, Glasgow—are requiring a vast number of wagons to load up imported goods for the interior, and as these imports are normally much greater than the exports, a steady stream of empty wagons is always being sent in to the ports. Every day at the greater number of stations on local or rural lines goods are coming in with articles for local consumption and wagon empties are "made" at these stations, and they have to be transferred to industrial district stations where a greater number of wagons are required for manufactured articles. At junction stations every day a stream of empty wagons is coming on and off the line, and those coming on have to be directed to points which are demanding wagons. Then there are special or seasonal traffics such as the annual despatch every autumn of the agricultural harvest, meaning a great demand for wagon stock at all country stations; the late spring import of timber requiring a vast array of wagons at places like Grimsby, Hull, Hartlepool, Cardiff, Leith; or again, fish wagons for the despatch of the herring harvest every summer as the fisherfolk follow the herrings round our northern coasts.

And apart from all these general merchandise commodities there is the question of coal conveyance from the collieries—to a large extent conveyed in private owners' wagons, but in the North-East of England and in Scotland carried like all other goods in railway owned wagons.

We have named some of the principal circumstances which affect wagon distribution; but there are endless others, even as regards the supply of ordinary vehicles. Every railway company has a great number of specially constructed wagons, as for example boiler or trolley wagons—long wagons supported on bogies, and built to carry heavy boilers or stern frames or bridge machinery—of 20-, 25-, or 30-ton capacity. Then there are many 25- or 15-ton wagons built for special service in ordinary traffic; there are 25-ton wagons for the conveyance of ironstone; 50-ton goods wagons for bricks; special prize cattle vans; cattle wagons fitted with continuous brakes; gunpowder vans; and many other descriptions.

Special control has to be kept over all these classes of wagon, and it is done on much the same principle as that referred to in connection with the car accountant in America, only here each vehicle is recorded upon a card instead of upon the page of a ledger. The daily work and location of each of these special wagons is kept track of by the wagon controller or his assistant by means of a card system of indexing —one wagon, one card. This card record, it will be seen, is on much the same lines as that set out on page 210, as that of the American ledger. Below is given a section of a sample card, which records the details of service of L.N.E. Railway trolley wagon 5499 for one month.

The number of wagons owned by the L.N.E. Railway, it has already been stated, including brake vans, is 279,639;* the L.M. & S. Railway corresponding figure is 308,122. The L. & N.E. Railway, in view of the immense increase both in area of control and in number of wagon stock, have deliberately kept their wagon control arrangements under their wagon controller separate from their new arrangements for *train* control. The whole of the large wagon stocks of the constituent companies have been amalgamated, and are being worked from one central control office in the manner already described in this chapter, and it is considered that this in itself is a large enough undertaking to perfect as a system without the complications of the new train control arrangements being mingled with it. The varying arrangements for wagon control and distribution in the six different companies have all been brought together under one central office at York, and there are now 24 district

TROLLEY WAGON NO. 5499.

Carrying Capacity 20 Tons. Flatrol.

Date.	From.	To.	L. or E.	T.	C.	Remarks.
1925.						
Jan. 8	York Shops	York, So. View	E.			For orders.
9	York	Goole	E.			W.
10, 12		At Goole	E.			W.
13	Goole	Middlesboro'	L.			
17, 19, 20		At Middlesboro'	L.			
21	Middlesboro'	So. Stockton	E.			W.
22		At So. Stockton	E.			W.
23	So. Stockton	Sunderland	L.	✓		
24, 26		At Sunderland	L.			
27, 28		At Sunderland	E.			S.
29	Sunderland	So. Shields	E.			S.
30, 31		At So. Shields	E.			S.

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* December 31, 1924.

wagon control offices extending from London in the south to Aberdeen in the north, with 121 local control points, the adjustment between all these in the daily distribution and allocation of wagons being made by the York wagon control office.

As regards the L.M. & S. Railway method, we have explained this in some detail in Chapter XII, and pointed out the great advantages which it is claimed arise from amalgamating the business of wagon control with that of the train control in the one central office at Derby.

As regards the L.N.E. Railway system where the two controls—train and rolling stock—are maintained under separate supervisions, the train control telephone machinery contributes valuable help locally, and in some degree also at headquarters, in compiling necessary information, and in working trains of empty wagons as required by the wagon controller. The two supervisions working in harmony mutually help one another.

CHAPTER XVII

THE ROLLING STOCK CONTROLLER

II. CARRIAGES AND PASSENGER STOCK

THE distribution of carriage and passenger stock follows in its main features the system just described as in operation for goods wagons, so there is not much to be said further as to control and allocation. The main difference between the two classes of vehicle as affecting control and organisation is (1) that the freight stock is much larger in number, and (2) that a large proportion of the passenger vehicles work day after day on the same journeys, backwards and forwards in regular routine, or " roster " as it is often called. It is only the balance that needs special control.

This balance, however, is no small factor in itself; there are horse-boxes, prize cattle vans, motor-car vans, milk vans, fish wagons, passenger saloons, and a great number of miscellaneous special vehicles, all of which are carefully controlled by a system of cards kept in a cabinet in the passenger stock controller's office. Each card is entered up daily after the daily census is obtained, and the card bears the record of work performed, miles run, etc., and in the case of saloons, the day by day earnings.

The total passenger train vehicles (1924) in Great Britain was 72,823, of which 51,238 are passenger carriages, and about 22,000 special vehicles running with passenger trains. The rolling stock controllers of the two large companies have 27,000 and 21,000 passenger vehicles respectively under their control. As with goods wagons the passenger stock is on the L.N.E. Railway under a passenger stock controller—a functionary apart from the train control office, whilst on the L.M. & S. Railway the passenger stock control is *part* of the central train control organisation, and is supervised by an assistant controller (carriage stock), who acts as assistant to the chief train controller.

Probably more than half the passenger carriage stock of Great Britain is running in regular service day by day, requiring no control or daily distribution in the same sense as goods wagons or horse-boxes which have to be daily allocated to their work. The carriage stock, indeed, divides itself under three categories, namely, the scheduled service carriages which have just been referred to ; the spare stock which is located in various parts of the system for regular strengthening of trains at periodical intervals, e.g. market days in rural districts, Saturday or week-end traffic ; this is known as " market stock," or " spare stock for strengthening." Then there is the balance —a third category—which constitutes a margin of available carriages—for excursion working in the summer or for use whilst the normal stock is in shops for repair. This stock naturally consists in large part of the older carriages of the companies, as the new stock goes at once into regular daily service.

During the summer months, there is great demand for extra carriages for excursion working, and one of the functions of the carriage controller is to see that as many vehicles as possible are available for the running of excursion traffic. Indeed, during the summer time the running of excursions which the company advertise is determined by the stock available.

The special functions exercised by the control office at Derby, now that the rolling stock and trains control have been brought together, have already been fully discussed in Chapter XII (see pp. 163–165), and need only be briefly referred to here. The system of dealing with " extras " has also been explained. A board is displayed every day on the office wall, which indicates all the extra carriages (i.e. carriages over and above the normal " make up " of a train) which require to be put on the train either for special party or for market day requirements, or for other strengthening purposes. Upon any special party being arranged for in advance where an extra carriage or vehicle is required, the control office is advised : that office keeps a register of these requirements, and it is thenceforth the responsibility of the controller to see that the carriage is provided and placed on the train. As the date approaches the carriage is arranged for, and every night at midnight the "extras" board is altered so as to post up, for all in the office to see, the passenger train "extras" for the ensuing two days.

A copy of the passenger trains extras card (down trains) in use at the Derby control office of the L.M. & S. Railway is set out on page 223 (Fig. 43).

It will be seen from what has been said as to the control of passenger vehicles that the Derby office has complete control over both trains and vehicles on both the passenger and goods working side.

So long as a company is able to steer clear of the difficulties and dangers inevitably attaching to so great a concentration of differing duties, it is manifest that there is advantage in bringing the two controls (of trains and of vehicles) into as close juxtaposition as possible. The arrangement of special telephones linked up by an exchange for the specific purpose of train working constitutes undoubtedly a mechanism of the greatest value to the stock controller, and it is easy to see in such a case as the daily allocation of wagons—or of carriages—necessitating the special working to any point of a number of empty vehicles—that there is great advantage in making decisions as to movement of vehicles to have the machinery for working them forward in the same office and under the same control as is the allocation itself.

But the difficulties of a combined office are great and serious, and it seems clear that they can only be met by a very considerable modification in organisation and personnel. Whether this is or is not worth while responsible officers in authority will have to decide. The question of the effect of the impact of the new control arrangements upon the organisation as well as upon the individual is dealt with in Chapter XVIII.

One point in conclusion may be urged that whatever be the precise arrangements for the control allocation and distribution of carriages, wagons, or other stock, the results of present management under which the public requirements are so efficiently and adequately met must incite the admiration of every thoughtful student of the methods of big organisations.

DOWN TRAINS.

Train.	From	To	Extras.	Tons.	TRAFFIC.		Position.	Forward Working.	Advice sent to	Entered on Extras Card.
					From	To				

FIG. 43.—PASSENGER TRAIN "EXTRAS" CARD. DOWN TRAINS.

CHAPTER XVIII

GENERAL EFFECTS OF THE NEW TRAIN CONTROL

THERE are two points of general interest that it is well that we should now give consideration to: firstly, the very important effect that the new method of control must have upon the individual human unit; and secondly, and not less important, the general effect upon the organisation of a railway company, which undoubtedly is far reaching.

The effect upon the human unit is considerable. The reader cannot have failed to notice, even where the point has not been specifically emphasised, how the development of the new systems which have been described exercises a constant influence upon the individual worker. The subject may perhaps be considered one of general economics rather than specifically one of railway operation, but it is one of the greatest practical importance, and no student can afford to overlook it.

The introduction of the electric motor truck on a station platform for the parcels porter's work is a good illustration of the considerable effect upon the character of a parcels porter. The electric motor hauls his parcels from point to point on the station platform. The electric motor superseded the old-fashioned hand barrow; indeed, one electric motor displaced some half-dozen barrows. The barrow itself is a powerful help to a man in the prosecution of his work, but as soon as the motor is introduced, instead of assisting the man to do his work, it actually does the work itself under the man's guidance or direction. Moreover, it carries the man himself along with the machine, thereby saving any exertion of his own in muscular energy. The porter really becomes a locomotive driver in miniature. And in connection with a change of this kind the question may very properly be asked, and should be very carefully considered as one of the most important points in economic science : What is the effect upon the character of the man ? What is the effect on his physical and moral development ? Is he, on the whole, a better and more qualified human unit now that a mechanical appliance has come to his aid and is doing his work for him ? Can he command as high a wage, or, now that his work is so much easier, should it be paid on a lower scale ? This illustration of the effect of a mechanical appliance upon the station shows conspicuously how mechanical aid affects human effort and human character. Drivers, firemen, guards, are all being similarly affected in greater or less degree by the introduction of mechanical aids. We saw that with power-signalling the signalman's manual labour is eliminated, and that in the case of engine-driving the introduction of electric power in place of steam, in addition to easing the driver's work, actually renders unnecessary, in many instances, the fireman's work altogether.

The new telephonic train control is a mechanical aid on a large scale, and we may therefore expect that it should result in great modification upon the work of individuals in various grades of the staff. We may consider first the effect on a goods guard's work. This functionary's normal duties include the custody of the various consignments of traffic in the goods train for which he acts as guard. It is further his duty to keep a record—the guard's journal, it is called—of the train journey, noting its arrival and departure time at the various stations at which it calls ; the wagons attached at each station ; time lost by detention at signals *en route*, or extra time taken at stations at which it calls, in shunting or in other ways. These are amongst the principal functions of a guard's work. When a train comes to be watched from a centralised office concurrently with its actual working the train record of arrival and departure times, time absorbed in shunting at stations, or in detention at signals are recorded in the central control office, and although in most cases up till now the guard continues his work as hitherto, a large proportion of the record taking which has hitherto been included amongst his duties becomes unnecessary, as it is obtained by other and more direct means. It is quite possible that within the next year or two as centralised train control becomes a more accepted and established method even the guard's journals themselves may be abolished, and this will affect very definitely the whole status of a guard. In a previous book * the writer has pointed out the necessity of a goods guard becoming in the future a more educated worker than he has been in the past because of the additional duties likely to be thrown upon him, especially that of keeping the records of the weight of his traffic and trains in tons, and upon a more accurate basis of figures than is the practice in England to-day. Everything has been pointing to the need of better qualified men for train guards in the future.

The train control office, however, itself is in many instances already keeping a record of the weight of trains in tons, and it furnishes to the manager a new, and quite easy, method of obtaining what is wanted. In this way, indeed, the new train control system may provide a solution of what has been one of the difficulties before railway managers in obtaining a record of the weight of their trains. But it seems quite definitely *to lessen the need* of a more educated man as guard in charge of the train. So far we have been speaking of the goods train guard only. The same question is raised, though in lesser degree, in regard to the guard of a passenger train. Several of the passenger guard's recognised duties may in future be undertaken by the control office.

We may consider it also as affecting the signalmen, and in this direction, too, the consideration becomes a very important one. We have seen (in Chapter VII) how the signalman's area of supervision and direct responsibility has been increased under the growth of telephone systems. At an important railway centre a signalman to-day is provided with telephones by which he can communicate 12 or 15 or more miles, at any rate, on either side of the station and ascertain the precise circumstances of approaching or passed trains, and his area of supervision has been increased accordingly. At many important railway concentration points the signalman is vested with authority to determine on which of two parallel roads the train may run where such parallel roads exist; or in other cases where a main line train is running behind time, or out of course, whether goods trains or less important passenger trains shall be allowed to leave his station in front of an express under the margin available. When a train control system is introduced into his district, the signalman's authority is affected not a little. Instead of deciding on his own, he can only decide what is the right thing to do after he has consulted the control office, so that his power of independent decision is very greatly modified: It is quite commonly found that the signalman, in the first instance, raises some objection to interference of this kind, and it is no easy point to say definitely whether the signalman's responsibility is increased or diminished.

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* *The Principal Factors of Freight Train Operating,* chap. v.

The position in which he finds himself really is this, that the new and efficient instrument of supervision introduced over his head becomes not only a director of his mind and movements, more or less autocratic in accordance with the controller's natural temperament, but brings him into conversational contact with a superior agency which can be consulted at any time, and by consultation he is able to obtain a very much wider and more accurate knowledge in regard to the position of trains and of the circumstances which would enable him to come to a right decision as to what preference should be given to this, that or the other trains which is standing at, or passing by, his station. In other words, the decision to let a train move forward is taken with much greater knowledge than before, and really is the decision made by the signalmen and the controller *in consultation.* This undoubtedly will reduce any cause for anxiety on the part of the signalman, but his responsibility is not reduced—rather the reverse.

Then there is the case of the engine-driver and fireman. They are not so directly affected as will be gathered from what has already been written about their position. The enginemen, however, are affected in this way, that a complete train telephone control system should make train running more punctual and effective all round, and more confidence in their ability to run to scheduled time should be engendered as a result of the feeling that the whole train working machine is more efficient, just in the same way that block signals tend to give the drivers more confidence in running. The case is different with goods trains, whose enginemen run with less regularity than the passenger trains, and many of which are not booked at all, for in these cases the more watchful supervision that is brought to bear all round secures that an engine-driver, even when doing his shunting work at a colliery or works siding, quite away from all his superior officers, may and does, under the new system of telephone control, come under the new experience of having to realise that the superintendent's eye from headquarters is *constantly* upon him as he carries out his work. That this experience has a considerable moral effect there can be no doubt. It will increase the driver's sense of his responsibility.

We have now referred to the effect of train control upon the goods guard, passenger guard, signalmen, and enginemen; and other grades are affected in a less conspicuous manner. But it needs here to be emphasised that the effect of the telephonic supervision as now developed is to bring into much closer relationship every grade of railway servant who is concerned in the running of trains. What has been spoken of in industrial circles lately with a good deal of emphasis, i.e. the team spirit, may and should, through the new telephonic system of train control, be introduced into train working with great effect. We may refer again to the signalman's position, where it was pointed out that the decision of giving one train preference over another, or of selecting which of two parallel lines (main or independent) a particular train should be allowed to take is registered as the result of the signalman's mind in combination with the superior mind of the headquarters staff. This same principle of a united mind of various officers concerned when a station master, local superintendent, or yard master decides a point and gives instructions is constantly at work. A local goods agent or yard master who is in direct telephonic communication with the goods station staff—foremen and checkers particularly—is able towards the end of the day to give various instructions as to disposal of goods on hand and ready for forwarding to-day, which instructions are no doubt dependent upon information to hand, mainly telephonic, in regard to forwardings expected the following day. The information being transmitted to the station staff enables the latter to take a more reasoned and intelligent interest in the work they are performing; and the whole staff—the whole organisation we may say—carries out its duties with one well understood aim; the team spirit works; over a wide area the foremen and checkers or loaders, as the case may be, themselves become more responsible as they come more into contact with the mind of the masters and into possession of the reasons by which the officers are actuated in issuing instructions.

The whole organisation, indeed, as well as the individual becomes considerably affected; and it may be fairly surmised that as the new telephone control for train working comes into play more generally as a mechanical assistance of the superintending organisation, an influence with far-reaching effect is being brought to bear on the whole railway system, in greater degree in those departments which are more directly concerned with train working.

The superintendent's department is the one that is being most affected by the establishment of train control systems, for its principal occupation is in connection with the running of trains—the central part of a superintendent's work. We have seen how it tends to bring the superintendent into more effective or authoritative connection with the manipulation of the locomotive, and with some companies is leading to a transfer of responsibility for engine supervision from the mechanical engineer to the operating superintendent.

In giving a more direct supervision over train working currently with the hour by hour operation it gives a more direct method of keeping all records, and is already superseding the method of train recording in ponderous books entered up some days after the actual running from the guard's journal reports. Even if the old style of train recording books be kept up in the superintendent's train recording office, they are more easily entered from the report sheets made up in the controller's office whilst the trains are running than from the less careful figures of the guard's journals. But as regards the principal trains—of which the running records are entered up in the control office—the train sheet on which the information is entered will take the place of the train running book, and to a large extent the recording of trains from the guards' journals may be superseded. As the trains office has in the past formed so large and so important a section of the superintendent's office, the change involved as here described is considerable. It must not be too hastily embarked upon, and it can only be adopted in the case of such trains as are specifically referred to the train control office. With such trains, however, the necessity for a vast number of enquiry forms being despatched at the end of each month, or periodically, to ascertain from station master or signalman the reason of detentions or delays during the month that has gone disappears, for the supervision has already been performed and steps taken as far as possible to prevent any recurrence of avoidable delays. This becomes possible, however, only when a more responsible and experienced officer is placed in charge of train working.

For the administration of a train control successfully a controller of good experience and training is essential, and the success of the new system may be said to depend upon this item more than any other, namely, the selection of a capable and experienced train manipulator as the controller in charge. Such a controller, as was pointed out in Chapter X, really becomes a general superintendent's most important assistant so far as all train working arrangements are concerned, and when such an organisation has eventuated and the train control arrangements have become recognised as an essential part of the superintendent's office and have secured the services of a principal assistant of the superintendent, there is naturally a tendency for the control machinery to be more and more used in connection with all complicated questions relating to train working where a central control is essential to good working—in such matters, for instance, as supervision of guards' vans, wagon control, arrangement of trainmen's hours, etc.

When the stage has been reached at which a control office can be extensively used in this way, the equipment of ready telephonic communication throughout the system comes to resemble a nervous system of communication between all parts of a living body, and the superintendent's working staff responsible for the various functions of the organism should be allocated in rooms conveniently arranged so as to debouch on to, or at least be easy of communication with, the central control office. In Chapter XII we have emphasised the importance of maintaining responsible heads of the train working department, each for his own special sphere of supervision, instead of attempting to let one head become controller of all sections at once. The success of the Derby system, which has so wide an area of supervision, is undoubtedly due to the fact that there exist separate supervisors or assistant controllers responsible for: (1) goods train control, (2) passenger train control, (3) passenger stock control, (4) goods stock control, (5) regulation of trainmen's hours and relief working, (6) allocation of locomotives, (7) mineral traffic control; all of these being subject to a chief train controller who takes rank as the principal trains assistant of the general superintendent.

In considering the question of the effect of the new method of train control upon the general organisation of the company we must distinguish between a local control and a general control like that of the L.M. & S. Railway centred at Derby. There are a number of local controls scattered about the country of varying degrees of authority and extent. The L. & N.E. Railway control at York—112 miles of the East Coast working—is, indeed, the only one outside the L. M. & S. system which is so large in extent as to warrant the description of a general control. Other controls are of a local character.

The effect of the control upon a company's general organisation may be assumed to vary in character in direct relation to the size and extent of the control system. The points as affecting changes in general organisation which have been referred to in this chapter hardly arise in connection with merely local installations where the controller has authority only over a section of the superintendent's trains office work; but the moral and intellectual effects upon the duties and upon the character of various individuals are always cropping up for consideration. They will generally be found to range round the question of the relative responsibilities which properly—that is, under a well-directed organisation—fall upon the various individuals or grades of workpeople concerned in the working of trains.

The whole question of responsibility is of so great importance and so vitally bound up with the general question of efficient organisation that it would seem well to devote the next and final chapter to a fuller discussion of the subject.

CHAPTER XIX

RESPONSIBILITY

There is perhaps no more serious difficulty attending the progress of a central telephone control than the danger which arises from the centralising of responsibility.

When a controller at headquarters exercises authority over the working of trains hundreds of miles away and is constantly advising a local signalman what is the right thing to do in cases of unusual working or of trains running out of course, the tendency on the part of the signalman is to become more and more reliant on guidance from above. The attitude of most signalmen when they find themselves, on the installation of a central control system, suddenly brought up against a super-imposed system of control is: "Well, if the controller is responsible for decisions as to the working, my responsibility is at an end." The point is of such importance that it is worthy of more consideration: for it is a widely held view that such a large power concentrated in a central office, enabling instructions and guidance to be promptly given to a local station master or signalman in cases where the latter has been used to giving decisions "off his own bat," must take away from the responsibility of the latter.

In a certain limited sense and on a superficial view of the matter it does so; but given good character and good will in the parties concerned it will not ultimately do so, and the two points to be emphasised in this chapter are:

1. The exchange of mind between controller and local agents increases the knowledge and efficiency of both parties, and greater knowledge eases labour, intensifies quality of work and, whilst it reduces anxiety, adds to rather than reduces responsibility.

2. The success of any system of central control will depend largely upon the recognition that devolution rather than concentration of responsibility is the true principle to apply.

. . .

We must discuss here in more detail than we have hitherto done how the new control affects the position of certain grades of official. The separate grades are differently affected, but if we consider the positions of signalmen, station master, and yard master or yard foreman respectively, by way of illustration of the principle involved, we shall have a sufficient range of variety to elucidate this somewhat difficult question.

The question is most commonly raised in the case of signalmen, as so constantly the signalman becomes a local control agent: let us discuss this case first. Imagine a signalman at a colliery or any private siding junction box who has a goods engine shunting or working in the siding. A message comes from control to the effect that the engine has been 30 minutes in the siding whilst under normal working and in accordance with ordinary regulations 20 minutes is ample time for him to do his work. Explanation is demanded, with a request that the engineman may be urged forward in his work so as to be despatched on his way as little behind time as possible.

The attitude of and the effect upon a signalman under these circumstances would vary according to his character. With many men it would be undoubtedly: "Who is this that is coming to exercise new authority and supervision over me. Why cannot I be trusted as hitherto to look after the engine shunting in my sidings without being ordered about by headquarters? But if headquarters is taking up this duty, I am relieved from any further responsibility in the matter."

Clearly this is a mistaken, and, indeed, a foolish attitude.

Under the former machinery of supervision what would have been the practice in a case like this? At the end of a week, a fortnight, or a month, the working of the train and the record of detentions or delay would have come under review and various enquiries sent out where considered necessary by the superintendent's trains-clerks or assistants on a retrospective survey. To-day, i.e. under "direct control," the supervising authority makes his enquiries concurrently with the detention. The comparison between the two methods suggests in connection with the older established practice the familiar adage about "locking the stable door after the horse has been stolen." The secret of success of the new method is that all subordinate officers, especially the district officers acting as local control agents, should be taken into full confidence at the outset and have explained to them the meaning of any change that affects them, and why the change of method is being adopted. Such explanation in ninety-nine cases out of a hundred will result in securing hearty co-operation between the local signal- or control-man and the central controller; the former, moreover, will soon realise that being in touch with central control brings him fresh assistance. HE CAN SHARE HIS RESPONSIBILITIES WITH HEADQUARTERS, and understand that instead of control being merely a disturbing and interfering element it becomes a means by which he can obtain assistance and often relief from anxiety. It becomes also an educative force, for it brings additional knowledge to the aid of the local agent; and additional knowledge brings, rather than takes away, responsibility.

Or we may take another and perhaps an even commoner case. A signalman at an important junction where there is a four-line track with cross-overs has been in the habit of exercising some control over trains in the way of deciding, in case of a train being late and out of course, whether any train affected should be diverted to the second track instead of its usual one, or whether he should give precedence in despatch to some goods train which would otherwise be held up. On a question of this kind it is manifest that a central train controller will, as a rule, be in a much better position to decide the point than the local controller; and if these decisions are taken by him instead of being made in the local signal-cabin it certainly looks on the face of it like a reduction of the signalman's responsibility. His mental worry and anxiety are undoubtedly reduced, but this is a different thing from responsibility. The signalman is in a better position to bear his responsibility.

We may admit that in one aspect, namely, that of independent power of decision, if that is our definition (a somewhat narrow one) of responsibility, this factor is decreased. But there is a better definition of responsibility than this: it is the power of being able to give a decision and to act promptly, wisely, and effectively. When the signalman can consult with a superior power who is in touch with all the factors necessary for right guidance, the decision—which the signalman gives effect to just as before—is a decision arrived at by joint minds. The signalman really becomes a part of the supervisory force always at work in the great supervising machine, and there is less excuse for him if he makes a mistake or a wrong move. He is a more, not less, responsible person. It is worth while to repeat the dictum already enunciated. Greater knowledge eases labour, intensifies quality of work, and adds to responsibility, whilst it reduces anxiety. This undoubtedly is a sound view as a general principle. Even though there may be in special cases a lessening of local responsibility, the more general effect is undoubtedly an all-round increase of the sense of responsibility.

The operation of this principle will be perhaps more readily appreciated by reference to a somewhat higher grade official such as the station master. Under any central telephone system in a superintendent's department, a station master is much more constantly in touch with the superintendent; orders and instructions come through more promptly on the one hand, and on the other when the station master is in any difficulty or anxiety he can much more promptly secure relief or assistance in his difficulties by consulting higher authority. Anxiety is lessened and responsibility is increased. And it is the same principle that is at work in all directions and with far-reaching effect with the more efficient telephonic apparatus now known as central train control.

The case of yard master is instructive in this connection. Some years ago the writer came across the case of an important control office at the entrance to a very busy marshalling yard which, in addition to controlling all the trains in the area for several miles round, had also assumed, under instructions, control of the yard working—even to the extent of allocating the use of sidings according to wagon destinations; and changes in the allocation such as exchanging for a specific destination a shorter for a longer siding were all determined by the controller. What in this case becomes of the yard master's or yard inspector's responsibility? Normally it is one of the functions of the yard master, that is the inspector or agent in charge of the yard and conversant with the ground, the yard working, and the traffic to be dealt with, to determine how the sidings under his control can be used to best advantage. If the controller assumes this function, it is almost certain to decrease the sense of responsibility of the yard master. Where two co-ordinate officers, such as controller and yard master, have responsibility for the same function there is especial need for care to be taken to define with whom *the leading responsibility* rests.

The position of yard master is itself so important a function and is so distinct from the work of train movement, that it would appear of prime importance to make the office as responsible a post as possible. The yard master needs to be kept very fully informed of train and traffic movements affecting his sidings, and for this he should be in constant communication with the controller, but all arrangements should tend to establish and develop his responsibility, not to weaken it. In many cases throughout the country it will be found the controller loses touch of his trains when they are off the running lines; they are no longer under control; or, in other words, they are "out of bounds." Someone else then becomes responsible, in this case the yard master.

On the other hand, as described in what has been called the Derby system, the trains remain all day long in charge of "control," whether running on the main line or shunting in the yards; but in this case the arrangement is bound up with a difference in general organisation. Though he does not bear that name, the local controller is, to all intents and purposes, a district superintendent, and he has charge of all movement of trains or moving engines throughout the district.

Reference to the description of the train control board in Chapter XII will show that the board in one of the L.M. & S. district control offices is so arranged that when trains or engines are off the running lines and in the terminal or marshalling yards, the corresponding tokens come off the time board, or time portion of the board, and are hung only in the margin at the side: They are no longer "under control" from the control office. The yard foreman must then assume supervisory responsibility, and inform the control office when his train is ready to resume its forward journey, consulting with the controller as he finds necessary.

The controller is in a superior position from the point of view of general knowledge of the railway circumstances, and from this very fact he may often detect a point where some change of arrangements is desirable which the local foreman had not noticed. Under such circumstances it is his duty to point out the matter to the yard foreman and make a suggestion.

It is essential that the controller should recognise that continual devolution of responsibility to the man on the spot is a primary principle of successful control. For, because of the accumulation of information and wide control, there is a continuous tendency to increased responsibility and to a widening of the control office functions, and therefore there is danger lest the office become overloaded with work and responsibility. It is of vital importance that there should not get abroad the idea that the development of a control office is going to reduce in any way the responsibility of local officers.

This question of the relative responsibilities of controller and yard master has been further dealt with in the chapter dealing with the York installation, where the problem is settled on different lines but in a way which has much to commend it, for it offers a solution on the lines that responsibility must be shared. The yard master needs the knowledge as to trains and traffic approaching his yard, and as to the capacity of the sidings of an adjacent yard to receive and deal with traffic he has to forward. The controller feels that he must not lose touch of a train when it enters an intermediate yard to "make-up" afresh after depositing a certain number of wagons.

So the office is divided between train movement and yard working, the latter forming a subsidiary section. Whenever a main line train enters a yard *en route*, e.g. York or Thirsk, the token comes off the control board as being out of bounds, but it is retained in the board margin as a reminder to the train controller. In another part of the office are assistant or yard controllers who are responsible for watching the engine and wagons whilst they are in the yards. These assistants become the counterpart in the office of the yard master and his assistants who are at work supervising on the ground, and so at any moment the yard working arrangements can be co-ordinated with those affecting train running; and this arrangement leaves the yard master's responsibility unaffected, or—most probably—enhanced because of an additional means of getting promptly into touch with all information affecting his trains and traffic. In Fig. 15 is illustrated the office arrangements at York. Through the agency of the assistant or yard controller there is co-operation and co-ordination firstly between the control office and the train work going on within the yard, and secondly within the control office itself between the movement of the engines in the marshalling yards and upon the running lines.

We may sum up what is accomplished by centralising train telephone control as being the bringing together of all the practical knowledge that is necessary at any one moment for efficiently supervising the complex organism of train working, and the ready distribution of such knowledge where it is most required: a central bureau is provided where information is accessible, and the telephone system is—or at least should be—so arranged as to make it *readily* accessible. This is a *sine quâ non* to success.

The fact that practically every officer connected with train working within the controlled area is carrying out his daily train work with full knowledge of the circumstances which are affecting the current running of trains can only quicken the sense of responsibility in practically all directions.

The mention of responsibility in connection with signalmen and train working almost inevitably carries with it the suggestion of risks of human life and the liability for accidents. The writer is not infrequently asked whether the increased control in the supervision and manipulation of trains means a greater or less measure of safety in working. On this point it must be borne in mind that there is no question of interference with the signalman's control of block working; from this point of view alone the importance of non-interference with the signalman's responsibility will be appreciated. An answer to the query raised can best be given on general lines that the new power of control adds greatly to the efficiency of supervision in train working; and any improvement in efficiency means, *ipso facto*; a greater degree of safety in manipulation of train running. In any case of accident or emergency the control office is able immediately and without any loss of time to put in hand the best possible working arrangements to meet the occasion, and it provides the necessary machinery for immediately advising everybody concerned of the emergency or of altered arrangements for " carrying on " which have had to be made. So that whilst all the normal means provided to secure safety in working remain untouched, the methods employed in coping with any emergency are largely improved with the result that in case of accident or any other interference with ordinary arrangements the improved control arrangements secure that only a minimum of inconvenience need be occasioned.

Our study of the question of responsibility and of the effect of the new methods of train control may fittingly conclude with once more emphasising the necessity of constant devolution of executive authority as the secret of successful control—the antidote against the danger of undue centralisation. In thus emphasising the importance of constant devolution it is interesting to recall the opinion expressed by Sir George Findlay, a former general manager of the L. & N.W. Railway, many years ago in his useful little book *The Working and Management of an English Railway*. Speaking upon the claims of responsibility in railway work he stated his view thus :

> " In fact the secret of organising a great service such as a great railway system is nothing more than a carefully arranged system of devolution combined with watchful supervision."

Though these words were written many years before the introduction of train telephone control, they deserve again to be emphasised in any consideration of the new methods which telephone development has made possible.

APPENDICES

APPENDIX I.

BLOCK TELEGRAPH BELL SIGNAL CODE.

BLOCK TELEGRAPH BELL SIGNALS TO BE GIVEN.

Call attention		1
*Attend to block bell telephone		1 pause 1
Is line clear for	Express passenger train, or breakdown van train going to clear the line ?	4 consecutively
	Ordinary or excursion passenger train, or breakdown van train **NOT** going to clear the line ?	3 pause 1
	Officers' special ?	1 pause 2 pause 1
	†Branch passenger train ?	1 pause 3
	Light engine going to assist disabled train ?	1 pause 3 pause 1
	Fish, meat, fruit, horse, cattle or perishable train composed of coaching stock ?	5 consecutively
	Empty coaching stock train ?	2 pause 2 pause 1
	Fish, meat, or fruit train, composed of freight stock: express cattle or express freight train ? **Class A**	3 pause 2
	Express cattle, or express freight train ? **Class B**	1 pause 4
	Through freight or ballast train ? **Class C**	4 pause 1
	Ordinary freight train stopping at intermediate stations ? **Class D**	3 consecutively
	†Branch freight or ballast train ?	1 pause 2
	Freight trains coupled ?	1 pause 1 pause 3
	Light engine or engine with additional tender attached, engines or engines and vans coupled ?	2 pause 3
	Train requiring to stop in section ?	1 pause 2 pause 2
	†Trolley requiring to pass into or through tunnel ?	2 pause 1 pause 2
	Out of gauge load ?	1 pause 2 pause 4
*Train entering section		2 consecutively
*Assistant engine in rear of train		2 pause 2
Train out of section, obstruction removed		2 pause 1
*Obstruction danger		6 consecutively
†Train arrived within inner home signal		4 pause 2

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* **Call Attention.**—This signal must always be given before any other signal, except those marked *, and must be acknowledged immediately on receipt.

† Only to be used where specially authorised by general superintendent.

Block Telegraph Bell Signals to be Given.—*Continued.*

Blocking back	Passenger trains :— **Inside** home signal— 3 pause 2 pause 1 **Outside** home signal— 1 pause 2 pause 3 Other than passenger trains :— **Inside** home signal— 2 pause 4 **Outside** home signal— 3 pause 3
Has train reached signal-box ?	2 pause 3 pause 2
Caution signal	4 pause 3
Stop and examine train	7 consecutively
Cancelling signal	3 pause 5
Train last signalled incorrectly described	5 pause 3
Train passed without tail lamp	9 consecutively **TO BOX IN ADVANCE** 4 pause 5 **TO BOX IN REAR**
Train divided	5 pause 5
Shunt train for following train to pass	1 pause 5 pause 5
Vehicles running away on wrong line	2 pause 5 pause 5
*Section clear to home signal only	3 pause 5 pause 5
Vehicles running away on right line	4 pause 5 pause 5
Opening of signal-box	5 pause 5 pause 5
Testing block bells and indicators	16 consecutively
Closing of signal-box	7 pause 5 pause 5
*Time signal	8 pause 5 pause 5
Lampman or fog-signalman required	9 pause 5 pause 5
Testing controlled or slotted signals	5 pause 5 pause 5 pause 5

---

* **Call Attention.**—This signal must always be given before any other signal, except those marked *, and must be acknowledged immediately on receipt.

APPENDIX II.

COAL SHIPPING ORDER FORM: (L. & N.E.R., HULL).

From..

....

....

Date..............................192..........

To the

LONDON & NORTH EASTERN RAILWAY CO.,

Mineral Traffic Controller,

HULL.

Having received a copy of the London and North Eastern Railway Company's regulations affecting the shipment of coal and their schedules of dues, rates and charges..hereby request that, subject thereto, you will ship by the..............................expected ready for loading..............................at.. Dock the coal named below:—

Total Tons.	Total Wagons.	Name of Colliery.	Kind of Coal.	Hold.	Consignee.

Time and date order received. Debit all charges to..

Signed..

This order must be presented (in duplicate) at the Mineral Traffic Controller's Office before it can be acted upon, and no other form will be acknowledged by the Company.

Coal required at ....*Dock.* .... A.M. P.M. *Sheet No.*............... ....192....

Item Number.	Coal and Coke Required for Immediate Shipment.								Stock at Sidings.*	Loads.		*Remarks.
	Colliery.	Quality.	Consignee.	Quantity.		Time required at Dock.	Vessel.	Appliance.		No.*	Number of Wagons.*	
				Tons.	Wagons.							

* Not for Dock use.

APPENDIX IV.

PASSENGER TRAIN WORKING, RECORD FORM: (L. & N.E.R., YORK).

DOWN.

				Engine.		
W.T.T. NO. 126	10.5 a.m.	E.P.	York to Edinburgh.	No.	Class.	192

Reporting Points.	D = depart. A = arrive. P = pass.	Time.			Remarks.
		Booked.	Actual.	Mins. Late.	
York	D	a.m. 10 5			
Thirsk	A				
	D or P	10 31			
Northallerton	A	10 41			
	D	10 46			
Darlington	A	11 5			
	D	11 11			
Ferryhill	A				
	D or P	11 29			
Durham	A	11 44			
	D	11 48			
Newcastle	A	12 8			

Reporting Points.	D = dep. A = arr. P = pass.	Time.			Wagons.					No. Class.				Remarks.
						Goods.		Mineral.		Load on Departure.				
											Tonnage.			
		Booked.	Actual.	Mins. Late.		L.	E.	L.	E.	Wagons.	Max.	Actual.	% Actual to Max.	
York Yard	D	p.m. 2 45												
Poppleton Junction	P	2 50			Att									
Thirsk	A				Det									
	D or P	3 32			Att									
Longlands Junction	D	3 55			Det									
Northallerton ..	P	4 0			Att									
Castle Hills.. ..	A	4 3			Det									
	D	4 16			Att									
Darlington Croft Jct.	A	4 48			Det									
	D or P	5 10			Att									
Parkgate	P				Det									
Bradbury	P				Att									
Ferryhill	A				Det									
	P	5 40			Att									
Relly Mill Junction	P	6 0			Det									
Durham	A				Att									
	D or P	6 6			Det									
Nowton Hall Jct. ..	A	6 12												
	D	6 35			Att									
Low Fell	P	6 56			Det									
Heaton Junction ..	A	7 20			Det									
Forth		7 15			Det									

APPENDIX VI.—DERBY CONTROL FORM.

MARSHALLING OF LEEDS TO CARLISLE PASSENGER TRAIN.

No............

Capacity of Platform.	Station Times.	Class of Engine.	Formation of Train.	Equal to		Engine Capacity.	Margin.
				Vehicles.	Tons.		
	a. m. LS 10 20	4 Leeds No. 5 turn	LS Glasgow / CS CF CA CH LS EO / CH CA LS ME / R LS ME / R (S) LS IN / P LS SN / F (MO)	12 (*M. & S. ex.*) 11 (*S. only*) 13½ (*M. only*)	189 176 212	265	76
8½	SN 10 54 10 56		LS Glasgow / CS CF CA CH LS EO / CH CA	9	153	265	112
25	HD 11 12 11 19		Manchester-Glasgow / CD CF LS Glasgow / CS CF CA CH LS EO / CH CA	12	205	235	30
10	AY 12 18 12 20						
	CE 12 53		LIMITED.				

Code.
LS = Leeds
SN = Skipton
HD = Hellifield
AY = Appleby
CE = Carlisle

Code.
ME = Morecambe.
IN = Ingleton.
EO = Edinbro'
For "Passenger Stock" code letters see Appendix IX.

MIDLAND RAILWAY PASSENGER AND GOODS STOCK.

Code for Rolling Stock, etc., used between Midland Stations only (prior to 1923).

PASSENGER STOCK.

	Code.		Code.
Bogie Compo.	A	First Class Saloon	FS
Bogie Compo. (Corridor)	CA	Fish and Poultry Truck	FT
Bogie Compo. (Lavatory)	BC	Guard's Van	R
Bogie Compo. (Vestibule)	VC	Horse Box	HB
Bogie Compo. Brake	BB	Hound Van	HV
Bogie Compo. Brake (Corridor)	CD	Invalid Saloon	JD
Bogie Compo. Brake (Lavatory)	D	Metro. Gauge Covered Carriage Truck	MCC
Bogie First	L	Milk and Fruit Van	P
Bogie First (Corridor)	LC	Motor Van	MV
Bogie First (Vestibule)	VL	Open Carriage Truck (16 ft.)	OT
Bogie First Brake (Corridor)	E	Open Carriage Truck (20 ft.)	LOT
Bogie Family Saloon	BFS	Parcel Van	PS
Bogie Family Sleeping Saloon	BFSS	Prize Cattle Van	PCV
Bogie Third	F	Restaurant Car	RC
Bogie Third (Corridor)	CF	Sleeping Car	SR
Bogie Third (Lavatory)	G	Slip Carriage	SC
Bogie Third (Vestibule)	VF	Slip Carriage (Bogie)	SB
Bogie Third (with four Lavatory Compartments)	LYG	Slip Carriage (Corridor)	CSB
Bogie Third Brake	H	Third	N
Bogie Third Brake (Corridor)	CH	Third (Lavatory)	LN
Bogie Third Brake (Lavatory)	J	Third Brake	O
Bogie Third Brake (Vestibule)	VH	Third Class Picnic Car	LSN
Bogie Third Saloon	BTS	Third Class Saloon	TS
Combination Coach	CC	Van (Bogie)	S
Compo.	K	Van (Bogie Corridor)	CS
Covered Carriage Truck	CT	Steam Fitted	Y
First Class Carriage	M	Westinghouse	X

CODE USED FOR IDENTIFICATION OF ROLLING-STOCK ON THE MIDLAND RAILWAY.

GOODS STOCK.

CATTLE.

	Code.
Calf Van (Piped)	CG
Cattle Wagon, Medium	C
Cattle Wagon, Medium (Piped)	PC
Cattle Wagon, Large	CL
Cattle Wagon, Large (Piped)	PCL
Cattle Wagon, Patent Partition Fastener	PFC

GOODS.

Banana Van (Fully Fitted)	BX
Banana Van (Fully Fitted) and with steam pipes	BXS
Fruit Van	SV
Fruit Van (Piped)	PSV
Goods Van	V
Goods Van (Piped)	PV
Goods Van (Fully Fitted)	FV
Goods Wagon (Piped)	PG
Goods Wagon (Fully Fitted)	FG
Low Goods Wagon	LG
Long Low Goods Wagon (8 tons)	LLF
Long Low Goods Wagon (10 tons)	LLH
Refrigerator Van	RV
Refrigerator Van (Piped)	PRV
Refrigerator Van (Fully Fitted)	FRV
Tariff Van	TV
Tariff Van (Piped)	PTV
Tariff Van Brake	TH
Tariff Van Brake (Piped)	PTH
Ventilated Van	VV
Ventilated Van (Piped)	PVV
Ventilated Van (Fully Fitted)	FVV
Ventilated Meat Van	MT
Ventilated Meat Van (Piped)	PMT
Ventilated Meat Van (Fully Fitted)	FMT

MINERAL, ETC.

	Code.
Coke Wagon	CK
Double Bolster Truck	DBT
End Door Wagon (8 tons)	EDF
End Door Wagon (12 tons)	EDK
High Side Coal or Goods Wagon (8 tons)	MF
High Side Coal or Goods Wagon (10 tons)	MH
High Side Coal or Goods Wagon (12 tons)	MK
Hopper Wagon	HP
Loco. Bunker Coal Wagon (6 tons)	LD
Loco. Coal Wagon (8 tons)	LF
Loco. Coal Wagon (12 tons)	LK
Loco. Coal Wagon (15 tons)	LM
Loco. Coal Wagon (20 tons)	LO
Loco. Coal Wagon (30 tons)	LS
Manure Wagon	MW
Rail Wagon, Long (12 tons, 31 feet)	RK
Rail Wagon (15 tons, 25 feet)	RM
Sleeper Wagon	SW
Timber Truck (12 feet)	T
Timber Truck Long (15 feet)	LT
Brake	B
Crane	CR
Sacks	SK
Sheets	ST
Timber Loaders	TL

SPECIAL WAGONS.

Armour Plate Truck (40 tons)	AP
Armour Plate Truck (50 tons)	LAP
Bogie Rail Wagon (30 tons)	BRS

CODE USED FOR IDENTIFICATION OF ROLLING STOCK ON THE MIDLAND RAILWAY.—*Continued.*

SPECIAL WAGONS.—*Continued.*	Code.
Bogie Rail Wagon (25 tons)	BRX
Bogie Tram Car Truck (15 tons)	BW
Boiler Truck or Trolley (15 tons)	TYM
Boiler Truck or Trolley (18 tons)	TYN
Boiler Truck or Trolley (18 tons) unrestricted	UTN
Boiler Truck or Trolley (25 tons)	TYR
Boiler Truck or Trolley (30 tons)	TYS
Boiler Truck or Trolley (30 tons) long	LTS
Boiler Truck or Trolley (30 tons) unrestricted	UTS
Boiler Truck or Trolley (40 tons)	TYZ
Boiler Truck or Trolley (60 tons)	TYY
Circular Plate Wagon (8 tons)	CP
Deep Case Wagon (5 tons)	DCB
Deep Case Wagon (8 tons)	DCF
Flat Wagon (15 tons)	FM
Flat Wagon (20 tons)	FO
Flat Case Wagon (12 tons)	FCK
Flat Case Wagon (15 tons)	FCM
Girder Wagon (12 tons)	GWK
Girder Wagon (15 tons)	GWM
Glass Wagon (6 tons)	GL
Glass Wagon (10 tons)	GLH
Gun Truck (60 tons)	GT

SPECIAL WAGONS.—*Continued.*	Code.
Gun Truck (100 tons)	LGT
Gunpowder Van	GP
Hollow Bolster Wagon (8 tons)	HBF
Hollow Bolster Wagon (10 tons)	HBH
Hollow Bolster Wagon (15 tons)	HBM
Hollow Bolster Wagon (18 tons)	HBN
Hot Armour Plate Truck (25 tons)	HAR
Hot Armour Plate Truck (40 tons)	HAZ
Implement Wagon (12 tons)	IPK
Implement Wagon (12 tons) unrestricted	UIK
Implement Wagon (15 tons)	IPM
Implement Wagon (18 tons)	IPN
Implement Wagon (18 tons) unrestricted	UIN
Iron Skeleton Wagon (6 tons)	ISW
Motor-car Van	W
Steam Fitted Van	SFV
Tank Wagon	TK
Traction Wagon (10 tons)	TRH
Traction Wagon (12 tons)	TRK
Tram Car Engine Truck (15 tons)	TEM
Wheel Wagon (6 tons)	WD
Wheel Wagon (18 tons)	WN
Wood Skeleton Wagon (10 tons)	WS

APPENDIX X.

SUMMARY OF WAGONS

Stations, Works, Collieries, Etc.	Loads Forwarded.		Number of Vehicles.															
	Other than Cattle.	Cattle.	U	E	R	S	U	E	R	S	U	E	R	S	U	E	R	S
TOTAL																		
..																		

[Form is intended to cover every class of wagon required.]

U = Waiting to be unloaded.
E = On hand empty.
R = Required for use.

8 A.M. SUMMARY OF WAGONS ON HAND, REQUIRED, AND SUPPLIED, OFFICE. REVISED FORM

BLANK FORM: (L.M. & S. CONTROL, DERBY).

Date...192.......

SHEETS.				ROPES.				CHAINS AND SCREWS.				SUPPLIED FROM AND TRAIN SERVICE.	Colliery Owned, and Private Wagons Supplied.	STOCK COAL.	
I	O	R	S	I	O	R	S	I	O	R	S			Railway Wagons.	Colliery and Private Wagons.

S = Supplied. I = In use. O = Out of use.

ETC., TELEPHONED FROM DISTRICT CONTROL OFFICES TO DIVISIONAL CONTROL AS IN USE AT PRESENT.

APPENDIX XI.

DAILY STOCK REPORT

Prefix SR	Time.	[illegible] of words.	[illegible] Inst. To.	[illegible] Sent.	[illegible]	[illegible] Inst. From.	[illegible] Received.	[illegible]

SECTION A. COMMON USER WAGONS AND LONDON & NORTH-EASTERN NON-COMMON USER WAGONS.		TOTAL Inward Loaded on Hand at NOON TO-DAY.	TOTAL Required for Loading TO-MORROW.	EMPTY on hand at noon to-day which will be available for loading TO-MORROW.	Inward Loaded expected to be emptied in time for use TO-MORROW.	Wanted additional.	To Spare.	Remarks.
Description.	Code.	L	R	O	U	W	S	RS
Short Open (Sides 2 ft. or less)	LOW							
Open (Sides over 2 ft.)	HIGH							
Open Lettered " Sleeper."	SLEEP							
Ordinary covered, (Up to 12 tons)	COVAN							
Ordinary covered ([illegible])	[illegible]							
Open lettered " Plate " (Up to 12 tons)	PLATE							
Open lettered " Plate " (Over 12 tons)	BOPLATE							
Single Bolster	SINGLE							
Twin Bolster	TWIN							
Double Bolster	DOUBLE							
Bolster fitted (30 tons and over)	QUINT							
Open, fitted with automatic brake or pipe	OFIT							
Covered, up to 12 tons (auto. brake or pipe)	COVFIT							
Covered ventilated lettered " Fruit "	FRUIT							
Covered ventilated, lettered " Perishable "	PERISH							
Lettered " Insulated " or " Refrigerator "	REFRIG							
Cattle, ordinary (include clean & dirty)	OX							†
Cattle, fitted with automatic brake or pipe, (include clean & dirty)	OXFIT							†
	SHEETS							
	ROPES							
FOREIGN NON-COMMON USER WAGONS.								

THE ABILITY OF THE COMPANY TO MEET THE DEMANDS OF THE PUBLIC DEPENDS PRIMARILY UPON THE
AND CAUSE DISORGANISATION

FORM: (L. & N.E.R., YORK)

Station.................................... (*Date*)...................... 192..

From..

To..

SECTION B. LONDON & NORTH-EASTERN VEHICLES.		TOTAL Vehicles Required for Loading To-MORROW.	TOTAL Vehicles Available for Loading To-MORROW.	Wanted additional.	To Spare.	TOTAL Vehicles expected Required for use DAY AFTER To-morrow.	Remarks.
Description.	Code.	**R**	**O**	**W**	**S**	**P**	**RS**
FISH TRUCKS.							
Open	OFISH						
Four wheeled covered (up to 12 tons)	COVFISH						
Covered (15 tons)	LAFISH						
Six-wheeled covered	SIXFISH						
Bogie Covered	BOFISH						
HORSE BOXES.							
Dual Brake	HD						
Westinghouse Brake Vacuum Pipe	HW						
Vacuum Brake Westinghouse Pipe	HV						
Six-wheeled	HK						
HOUNDS VANS.	DOG						
SPECIAL CATTLE BOXES.	SC						
OPEN CARRIAGE TRUCKS.							
Four-wheeled under 20 ft.	K						
Four-wheeled over 20 ft.	MK						
Six-wheeled	XK						*
Bogie	BK						*
COVERED CARRIAGE TRUCKS.							
Four-wheeled under 20 ft. inside	CK						
Four-wheeled 20 ft. and under 21 ft. inside	MCK						
Four-wheeled 21 ft. and over inside	LCK						
Six-wheeled	XCK						*
Bogie	BCK						*

† Give number of *dirty* cattle wagons included in the "O" figures. E.g. 9. dirty.
* Give the individual numbers of the vehicles shown in the "O" column.

....*Signature of Agent.*

CCURACY OF THE DAILY REPORTS. ANY INCORRECT FIGURES SUPPLIED INDICATE A LACK OF CARE
ND UNNECESSARY EXPENSE.